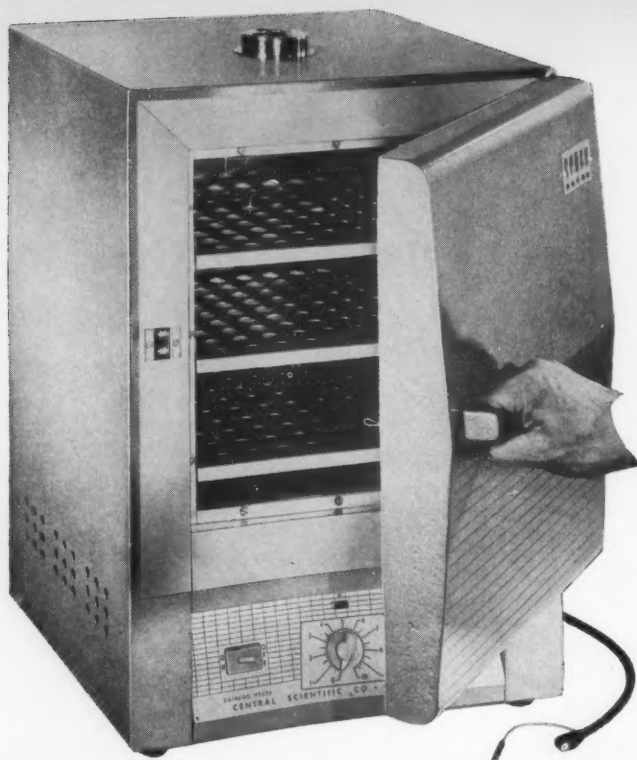


SCIENCE

5 April 1957

Volume 125, Number 3249

Editorial	World Health Day 1957: Food and Health	625
Articles	Fall of Parity: <i>L. S. Rodberg</i> and <i>V. F. Weisskopf</i>	627
	Outer Space in Plants: <i>P. J. Kramer</i>	633
	A. S. Pearse, Ecologist: <i>I. E. Gray</i>	635
News of Science	News Articles and Briefs; Scientists in the News; Recent Deaths	637
Reports	Effect of Somatotropin on Cells in Tissue Culture: <i>H. D. Moon</i> and <i>L. St. Vincent</i>	643
	Oxygen Consumption in Ovulating Fragments of Ovaries of <i>Rana pipiens</i> : <i>P. A. Rondell</i> and <i>P. A. Wright</i>	644
	Effect of Gibberellin on Germination of Lettuce Seed: <i>A. Kahn</i> , <i>J. A. Goss</i> , <i>D. E. Smith</i>	645
	Survey of Fungi and Actinomycetes for Compounds Possessing Gibberellinlike Activity: <i>R. W. Curtis</i>	646
	Occurrence of Iron, Copper, Calcium, and Magnesium in Tobacco Mosaic Virus: <i>H. S. Loring</i> and <i>R. S. Waritz</i>	646
	Enzymatic Conversion of D-Glucose to D-Fructose: <i>R. O. Marshall</i> and <i>E. R. Kooi</i>	648
	Neurogenic Inhibition of Shivering: <i>L. L. Boyarsky</i> and <i>L. Stewart</i>	649
	Mitosis in Adult Cartilage: <i>E. S. Crelin</i>	650
	Effect of Kinetin on Protein Content and Survival of Detached Xanthium Leaves: <i>A. E. Richmond</i> and <i>A. Lang</i>	650
	Temperature-Respiration Curve of Flour Beetles Exposed to Nonoptimal Temperatures: <i>D. K. Edwards</i>	651
Book Reviews	<i>Physical Methods in Chemical Analysis; Principles of Zoology; Research in the Effects and Influences of the Nuclear Bomb Test Explosions; Physics; New Books</i>	653
Meetings and Societies	Clinical Chemistry; American Nuclear Society; Meeting Notes; Society Elec- tions; Forthcoming Events	656
	Equipment News	662



This **NEW** Cenco Rectangular Oven gives you

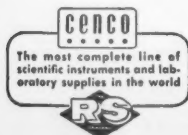
Constant temperature...
Precision control...
Increased safety

You'll appreciate the lasting dependability of this new Cenco oven. Its unique design insures constant, thorough circulation of heated air throughout the chamber without sacrificing maximum storage capacity. Nickel-chrome heating strips are sealed off from the air in the chamber to prevent gaseous explosions. Sensitive, hydraulic-type thermostat provides precise control of temperatures from 60° to 250°. Heat retention is assured by three inches of glass wool insulation.

The interior is entirely of stainless steel and glass inner doors are available when desired for observation without loss of temperature.

You have your choice of gravity or forced air circulation in two sizes.

No. 95075, Gravity, 12" x 12" x 14" inside.....\$288.00
No. 95080, Gravity, 17" x 15" x 20" inside.....\$367.00
No. 95375, Forced, 12" x 12" x 14" inside.....\$393.00
No. 95380, Forced, 17" x 15" x 20" inside.....\$472.00



The most complete line of scientific instruments and laboratory supplies in the world

CENTRAL SCIENTIFIC COMPANY

1718-M IRVING PARK ROAD, CHICAGO 13, ILLINOIS
BRANCHES AND OFFICES—CHICAGO • MOUNTAINVIEW, N. J. • BOSTON • BIRMINGHAM • DETROIT
CENTRAL SCIENTIFIC CO. OF CALIFORNIA—SANTA CLARA • LOS ANGELES
REFINERY SUPPLY COMPANY—TULSA • HOUSTON
CENTRAL SCIENTIFIC CO. OF CANADA, LTD.—TORONTO • MONTREAL • VANCOUVER • OTTAWA

Order today or write for Bulletin No. 6.

New (7th) Edition! an orienting text which not only describes the structure of the human body as seen with the optical microscope but which also considers relevant submicroscopic analysis and discusses function.

Maximow and Bloom's TEXTBOOK OF HISTOLOGY

The achievements of *Maximow and Bloom's* superb book have been well documented by many reviewers in leading journals. Down through the editions, praises have followed each publication date. The Journal of the International College of Surgeons said of the Fifth Edition, ". . . there remains but little that the reviewer can add about the present edition (fifth) except to sing its praises anew." The Sixth Edition also earned its share of encomiums in leading journals—to wit, ". . . carries on the Maximow tradition in this new sixth edition . . ."—". . . has proved its merits through six editions . . ."—". . . highly recommended . . .".

Now the *New (7th) Edition* proudly takes its place, ready not only to carry forward the privilege of serving as the number one textbook in its field but also to help establish the new frontiers of Histology. You will find recorded here the great advances in our knowledge of minute structure. You will find a book which can be recommended to both teacher and student for its logical precision, clear and succinct presentation, comprehensive coverage and its vast number of illustrations. 1082 of these, with 265 in color, help the text tremendously in its task of describing the minute structure of each organ of the body and explaining the functions of each of the cells that make up an organ. New understanding of tissue structure is achieved by the addition of scores of electron micrographs. *This is the finest collection of histologic illustrations ever published.*

Much of the book has been drastically rewritten and subjected to searching criticism, thus assuring readers that the *New (7th) Edition* gives them the kind of up-to-date and authoritative textbook they associate with the name "Maximow and Bloom".

Make this acid test—send for this book to examine and see for yourself how it renders your old edition obsolete.

GLADLY SENT TO TEACHERS FOR CONSIDERATION AS A TEXT.

By ALEXANDER A. MAXIMOW, Late Professor of Anatomy, University of Chicago; and WILLIAM BLOOM, Professor of Anatomy, University of Chicago. 628 pages, 7" x 10", with 1082 illustrations on 631 figs., 265 in color on 57 figs. *New (7th) Edition—Ready in April, 1957.*

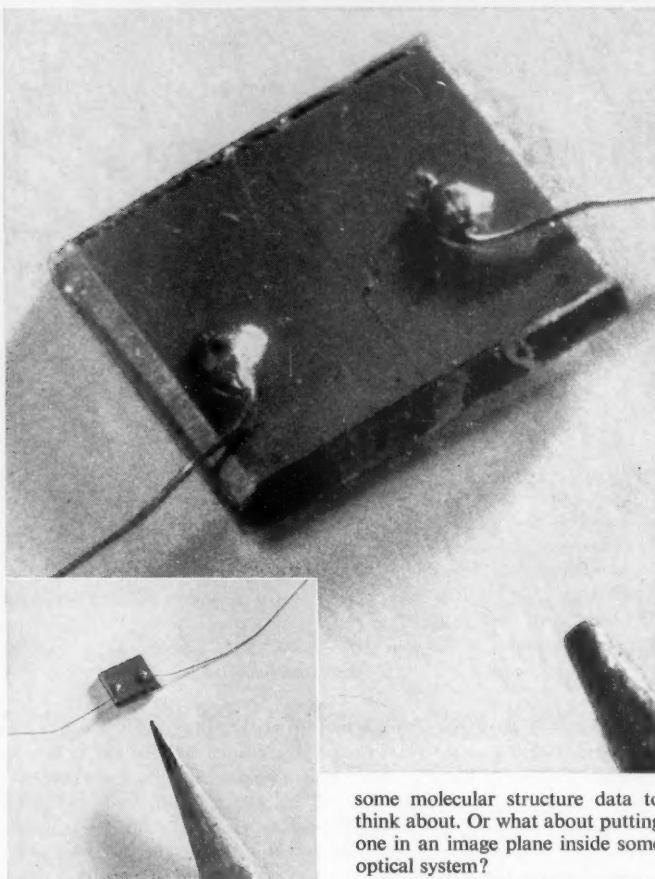
W. B. SAUNDERS COMPANY

West Washington Square
Philadelphia 5

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879. Annual subscriptions: \$7.50; foreign postage, \$1; Canadian postage, 50¢.

Kodak reports to laboratories on:

a photoresistor 20 μ wide ... a hydrocarbon among hydrocarbons



Thin receptor

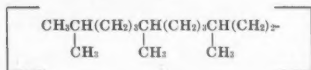
The thin black line is 20 μ wide and 0.2 mm long. In the dark, d-c resistance across the .0008" of lead sulfide is a few hundred ohms. When radiant energy shines on the line, the resistance drops. A manifestation, obviously, of the celebrated *Kodak Ektron Detector*. The wavelength of the energy can be from 3.5 μ in the infrared,* right through the visible and on to at least 250m μ in the ultraviolet. Imagine an infrared spectrometer that could afford to image its exit slit down to .0008"! Might provide

*That would make a receptor less than 6 wavelengths wide, wouldn't it?

some molecular structure data to think about. Or what about putting one in an image plane inside some optical system?

For \$23.50, paid to Eastman Kodak Company, Apparatus and Optical Division, Rochester 4, N. Y., anybody can have one. If the eloquence of these words gets us swamped, delivery may be a bit delayed. If you wanted to wait, it's not unlikely the price will drop. But then you might not be first on your block.

That ol' shark oil



This looks like a tedious concatenation of 30 carbon atoms and 62 hydrogen atoms, but oh, how wrong you would be to say that!

This is *Squalene*. (Note the "a.") We hereby announce our readiness to sell it as Eastman 7311 at \$15.60 per 100 grams. *Squalene* is hydro-

genated *Squalene* (Eastman P6966). We can distill squalene (Note the "e.") in our unique molecular stills from the oil found in the gigantic, oily liver of the mighty but leisure-loving basking shark. *Squalene* is being added to at least one brand of cattle feed on the strength of certain findings by the manufacturer about cholesterol and sex hormones. The merest *soupeon* of it in dog food is said to bring utter bliss to the canine palate.

The latest is that *Squalene* has a contribution to make to gas chromatography, which is booming. This is an analytical technique whereby a volatile sample mixture is swept by an inert gas through an adsorbing column and resolved by virtue of the different times it takes each component to make its way through against the adsorption forces. *Squalene* is reported (*Anal. Chem.* 28,303, March '56) to modify the adsorbing characteristics of a commercial carbon black in a manner that shuffles the order of emergence from what it is with other adsorbents, thus providing a good fix on the proportions of each different C₆, C₈, and C₇ saturated hydrocarbon present. One of our own plants tried it out and forthwith contributed further to the burgeoning art by discovering that *Squalene* is very good at separating hydrocarbons from oxygen-bearing compounds close to them in physical properties. They found, for example, that n-heptane emerges later than n-butanol, even though n-butanol is the higher boiling substance.

Will we reveal more about this? Will other experiments now in progress with *Squalene* turn out to be as interesting as the preliminary results promise? Don't wait for the next gripping chapter, if any. We sell *Squalene* with which you can go to work yourself. (You won't find it in our Eastman Organic Chemicals List, No. 40. It's too new. You will find some 3500 other organic compounds, though. If you haven't a copy, drop us a note.) Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company).

Prices quoted are subject to change without notice.

This is one of a series of reports on the many products and services with which the Eastman Kodak Company and its divisions are ... serving laboratories everywhere

Kodak
TRADE MARK

AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE

Board of Directors

LAURENCE H. SNYDER, *President*
WALLACE R. BRODE, *President Elect*
PAUL B. SEARS, *Retiring President*
PAUL M. GROSS
GEORGE R. HARRISON
PAUL E. KLOPFER
CHAUNCEY D. LEAKE
MARGARET MEAD
THOMAS PARK
WILLIAM W. RUBEY
ALAN T. WATERMAN
PAUL A. SCHERER, *Treasurer*
DARL WOLFE, *Executive Officer*

DARL WOLFE, *Executive Officer*
GRAHAM DUSHANE, *Editor*

CHARLOTTE V. MEETING, *Associate Editor*
JOSEPH TURNER, *Assistant Editor*

Editorial Board

WALLACE R. BRODE	EDWIN M. LERNER
BENTLEY GLASS	WILLIAM L. STRAUS, JR.
KARL LARK-HOROVITZ	EDWARD L. TATUM

Editorial Staff

PATRICIA L. CARSON, MARY L. CRABILL, SARAH S. DRES, NANCY S. HAMILTON, OLIVER W. HEATWOLE, YUKIE KOZAI, ELIZABETH MCGOVERN, ELLEN E. MURPHY, ROBERT V. ORMES, BETHSABE PEDERSEN, MADELINE SCHNEIDER, JACQUELYN VOLLMER

EARL J. SCHERAGO, *Advertising Representative*

SCIENCE, founded in 1880, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879.

SCIENCE is indexed in the *Reader's Guide to Periodical Literature* and in the *Industrial Arts Index*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: \$7.50; foreign postage, \$1; Canadian postage, 50¢. Single copies, 25¢. Special rates to members of the AAAS. Cable address: Advancesci, Washington.

The AAAS also publishes THE SCIENTIFIC MONTHLY.



World Health Day 1957: Food and Health

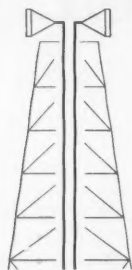
It would be idle to deny that the *political* achievements of the United Nations have been few and small. The world institution has been impotent to prevent hundreds of millions of persons from falling prey to a new despotism. It has been ready to enforce the will of a majority against law-abiding nations but has not even attempted to discipline lawless offenders.

By contrast, the *technical* aspects of United Nations work have been conspicuously successful, whether the work has been concerned with the fight against the great epidemic diseases, with literacy, or with the spread of better agricultural methods. The theme of the ninth anniversary of the constitution of the World Health Organization, "Food and Health," a theme jointly sponsored by the Food and Agricultural Organization, illustrates the fact that greater knowledge not only makes us more effective when action has been decided upon, but also makes us more responsible when weighing the decision to act for the benefit of all.

Until 1914 we could describe human nutritional requirements only in the vaguest terms. As a result, measures in the field of nutrition were limited to desultory charities on the part of wealthy individuals or organizations toward the "poor" of their country or the starving abroad. The period between the two World Wars witnessed an explosive development of our knowledge of human requirements for calories, amino acids, vitamins, minerals, and other dietary essentials. The figures corresponding to these requirements were tabulated, first by a committee called by the Health Section of the League of Nations, and later by many other national and international bodies. As our understanding grew, so did the feeling that it was intolerable that the satisfaction of precisely known needs should be left to the vagaries of weather or markets and not insured by systematic planning. Thus, as soon as World War II ended, FAO and its International Emergency Food Committee were ready to allocate available food stocks on the basis of demonstrated needs and calculated requirements. The crisis over, FAO continued to help its member nations to plan their agricultural and food policy with sound nutrition as the essential guide. WHO kept checks on the nutritional status of the more vulnerable groups, trained specialists, and explored with FAO the possibility of introducing supplementary foods to combat nutritional diseases. Lately, these two organizations and the International Children's Emergency Fund (UNICEF) have concentrated their efforts on the prevention of kwashiorkor, a deadly protein deficiency syndrome of infants weaned to a poor diet, which is widespread in Asia, Africa, and Central America.

In congratulating WHO and FAO on their achievements to date, we may take comfort in the thought that such results go even farther than the important fields of food and health. They provide a pattern of application of experimental knowledge to social phenomena which may someday help us to deal not only with the scourges of nature but also with the more perplexing problem of the inhumanity of man toward man.—JEAN MAYER, *Harvard School of Public Health*.

What kind of men develop microwave highways?

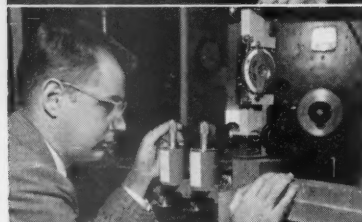


The great microwave systems that relay telephone conversations along with television programs from coast to coast will have to work harder than ever to meet growing demands for service. But at Bell Laboratories scientists have been making important advances in the art of microwave communication. These advances are being applied in the development of a new and more efficient system in which single beams of microwaves will carry simultaneously many more telephone conversations and television programs than is now possible.

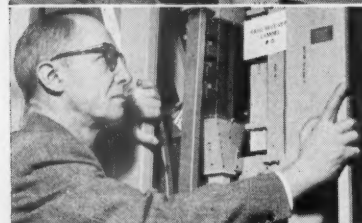
The development of the new system demands the varied skills of men in many fields of science and engineering. Just a few of the specialists necessary are . . .



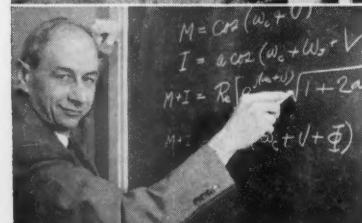
PHYSICISTS like J. A. Weiss, Ph.D. in Physics, Ohio State, to harness the properties of ferrites in new ways for better control of the transmission of microwaves.



MICROWAVE ENGINEERS like P. R. Wickliffe, M.S. in E.E., M.I.T., to design new circuitry. Microwaves must be conducted, controlled and amplified through waveguides which resemble pipes.



MECHANICAL ENGINEERS like W. O. Fullerton, B.S. in E.E., Iowa State, to embody new principles in designing the many structures and devices used in microwave telephony—with all parts feasible to manufacture, practical to install and easy to maintain.



SYSTEMS ANALYSTS like J. P. Kinzer, M.E., Stevens Institute, for over-all system planning and prediction. Mr. Kinzer works with numerical quantities and characteristics to predict on paper the performance of an operating system. What will it do? How must it perform to meet the needs?



ELECTRONIC ENGINEERS like B. C. Bellows, B.S. in Engineering, Cornell, for the development of "watch-dog" equipment to protect against failure. Protective devices must operate automatically in split seconds to maintain uninterrupted service.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



Fall of Parity

Recent Discoveries Related to Symmetry of Laws of Nature

L. S. Rodberg and V. F. Weisskopf

A number of recent experiments in nuclear physics have revealed that some of the very basic properties of nature seem to be different from what we believed them to be. It is rare in the history of physics that the results of only a few experiments force upon us a change in our fundamental principles. This is just what has happened now, and this essay tries to explain the situation.

Before describing the experiments themselves, we will discuss the basic principle which is attacked by their results. It is the *principle of parity*. This principle can be stated in the following form: any process which occurs in nature can also occur as it is seen reflected in a mirror. Thus nature is mirror-symmetric. The mirror image of any object is also a possible object in nature; the motion of any object as seen in a mirror is also a motion which would be permitted by the laws of nature. Any experiment made in a laboratory can also be made in the way it appears as seen in a mirror, and any resulting effect will be then the mirror image of the actual effect. In more elegant language, the laws of nature are invariant under reflection.

As an example, take a perfectly uniform bar supported in the middle by a pivot, as in Fig. 1. We all know that it will not tip, but let us prove this using mirror symmetry, or the principle of parity. There are three possibilities: (i) the bar could tip clockwise, (ii) it could tip counterclockwise, or (iii) it could remain horizontal. Suppose we place a mirror as in Fig. 2 (the dotted line represents the mirror). The mirror image

of the bar and its support is identical with the object. However, if motion (a) were the correct one, the mirror image would show motion (b) and not the correct motion i; hence, we have a contradiction to the principle of parity. Only the possibility iii is identical with its reflection and thus must be the correct one since the object itself is identical with its reflection.

Now we suppose the pivot to be frictionless and rotate the bar around the axis AA' (Fig. 3). The situation is unchanged since this rotation appears unchanged in the mirror. Then this rotation will not cause the bar to tilt.

Electromagnetic Radiation

Let us now look at a more sophisticated example. We will examine the radiation from an electric dipole. Such a dipole can be pictured, for example, as a charge which oscillates up and down in the z -direction (Fig. 4). We see, first of all, that the radiation pattern will be symmetric around the z -axis. This is because the electric dipole exhibits a cylindrical symmetry about this axis.

We will now use mirror symmetry to show that the intensity is the same above and below the x - y -plane. In Fig. 5 we illustrate the two cases. The mirror image of the oscillating dipole is identical with the object, apart from a phase shift of half a period. When the object moves up, the image moves down. However, the radiation intensity pattern is constant in time, and therefore it is not affected by this shift in time. We see that the mirror image of the radiation pattern labeled "right" is exactly like the actual one, as it should be, while the

pattern labeled "wrong" is inverted: the object has a stronger field downward, while the image has a stronger field upward. They cannot both be right.

Let us now look at the electromagnetic field associated with this radiation. Here we examine the instantaneous position of the moving charge, and of the electric field, since we know that after each half period the direction of the dipole and also the direction of the field strength change their sign. Let us suppose that the charge is moving upward. We know that the electric field must be perpendicular to the direction of propagation, and we would like only to decide the question of the relative directions of the electric field in two beams, one going upward and the other downward. In fact, we want to decide between the two possibilities marked "wrong" and "right" in Fig. 6. Using mirror symmetry, we can rule out the possibility marked "wrong." This situation cannot hold, for the dipole is turned around in reflection, while the electric field is not. (Alternatively, if we wait half a period, the mirror-dipole will point upward again, but the electric field will have reversed its direction.) On the other hand, in the situation marked "right," the electric field has "followed" the dipole upon reflection. (Here, if we wait half a period, the mirror dipole and electric field will reverse, reproducing the present actual dipole and electric field.) Then the situation marked "right" must be the true one.

On the other hand, a quadrupole consists of two dipoles opposite each other. It is thus unchanged when it is reflected in a mirror, so that we have the reversed case; the electric field of quadrupole radiation must be invariant upon reflection in a mirror, and the case marked "wrong" in Fig. 6 would be the correct one. We say that dipole radiation has an "odd" parity since E has changed direction; quadrupole radiation has an "even" parity, since E is unchanged.

We have used the electric field in this discussion since it alone specifies a direction (the direction of the force on a positive charge). This direction becomes the reflected direction when seen in a mirror. The magnetic field does not specify a direction, but only a sense of rotation (for example, the sense of rotation of a moving charged particle which produced it). However, the sense

The authors are on the staff of the department of physics and the laboratory for nuclear science at Massachusetts Institute of Technology, Cambridge.

of rotation is unchanged under reflection. It is important to remember here that the "direction" of the magnetic field is usually defined in terms of an arbitrarily chosen "right-handed screw." That is, we associate the magnetic field with a screw, which arbitrarily ascribes a direction to a sense of rotation in order to express it by a vector. This situation is usually described by saying that the electric field is described by a polar vector which changes direction under reflection, while the magnetic field is described by an axial vector, which does not change direction under reflection.

Let us now consider an object such as a screw which has a "spirality"—that is, a direction of motion associated with a sense of rotation (Fig. 7). Its mirror image has the opposite spirality and must also exist in nature, by our principle of parity. Thus, in Fig. 7, we see that we may place our testing mirror in two positions, one of which reflects the direction of motion but leaves the sense of rotation unchanged, while the other has the reverse effect. In either case, the spirality is changed.

An example is the tetrahedral molecule of Fig. 8. We see that the reflected

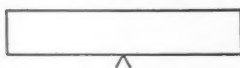


Fig. 1. Uniform bar pivoted in the middle.

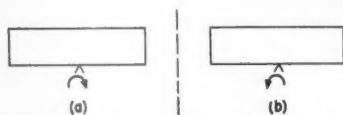


Fig. 2. Mirror image of bar. This illustrates the lack of mirror symmetry if the bar should rotate.

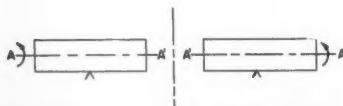


Fig. 3. Rotating bar viewed in mirror. The sense of rotation is unchanged by reflection.

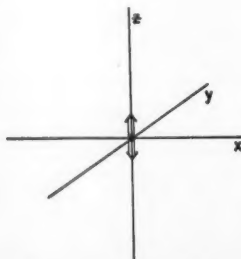


Fig. 4. Oscillating dipole.

molecule cannot, by any rotation, be made to be identical with the original molecule (just as we cannot turn our left hand in such a position that it looks like our right hand). Thus these are distinct molecules which, by the principle of parity, must both exist in nature. An example of this situation is the quartz crystal, composed of many of these molecules. This crystal illustrates on a large scale this "handedness." The principle of parity requires that both types of crystals be found in nature.

A well-known example is the fact that sugar occurs in two varieties. However, it is only the right-handed kind, glucose,

which is found in living matter. As physicists, we do not believe that this indicates an inherent handedness of nature; rather, we believe that it can be attributed to an accident which occurred at the origin of life. Life could just as well have developed by using levose instead of glucose.

Beta Decay

We now proceed to consider the actual experiments which have shed new light on this principle of parity, in particular, experiments on beta decay. All we need

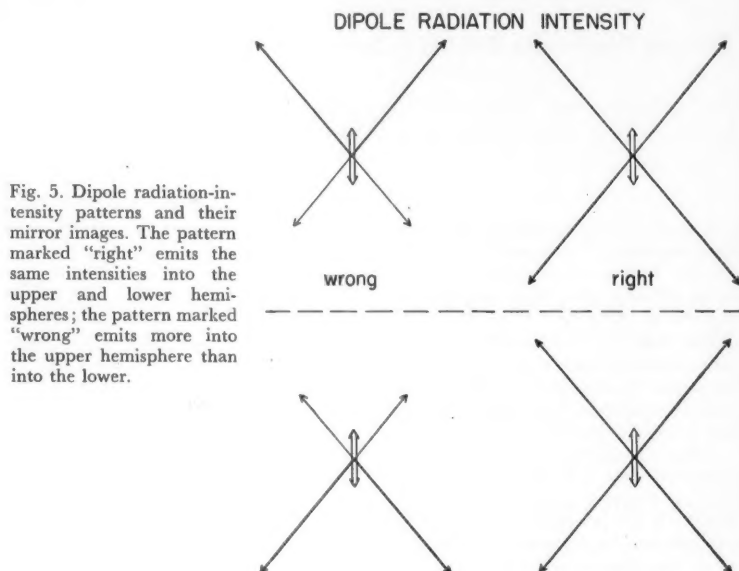


Fig. 5. Dipole radiation-intensity patterns and their mirror images. The pattern marked "right" emits the same intensities into the upper and lower hemispheres; the pattern marked "wrong" emits more into the upper hemisphere than into the lower.

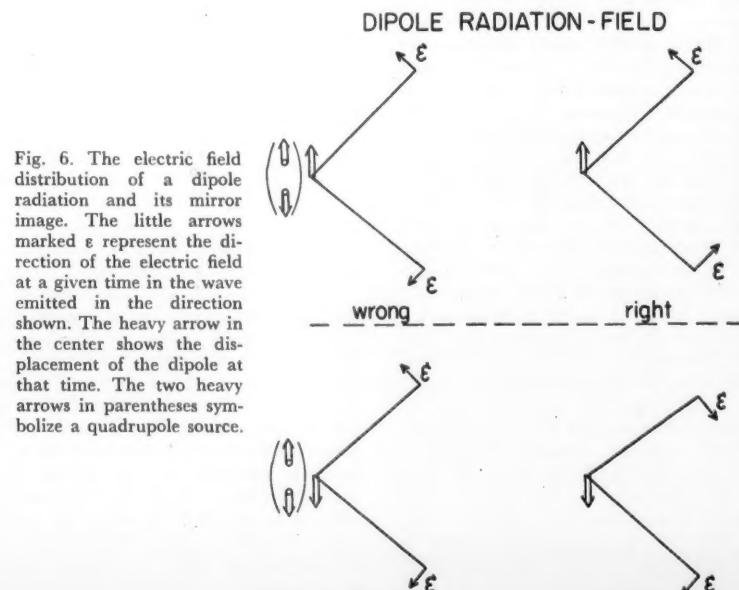


Fig. 6. The electric field distribution of a dipole radiation and its mirror image. The little arrows marked ϵ represent the direction of the electric field at a given time in the wave emitted in the direction shown. The heavy arrow in the center shows the displacement of the dipole at that time. The two heavy arrows in parentheses symbolize a quadrupole source.

to know here is that there are atomic nuclei which emit electrons along with neutral, massless particles known as neutrinos. For instance, the isotope of cobalt known as cobalt-60 becomes nickel-60 and emits an electron (e^-) and a neutrino (ν)



The cobalt nucleus has a spin—that is, it is rotating with a well-defined angular momentum when it is in its normal state. Now we ask: In what directions will the electrons emerge? In a normal piece of cobalt, electrons will emerge in all directions because nuclei are oriented in all directions because of the heat motion.

Suppose we orient the nuclei—that is, force all the nuclei to align their axes of rotation parallel to a given direction and have them rotate in the same sense. This is the difficult part of the experiment since it is so hard to “get hold of” the nucleus. The only way is through the magnetic moment arising from the spin. The spin can be forced into a given direction by an external magnetic field if we can reach temperatures of less than 0.1°K . Then it is possible to orient the nuclei.

What do we now expect? The nuclei are all rotating in the same sense. Let us apply the principle of parity. In a mirror (Fig. 9) they rotate the same,

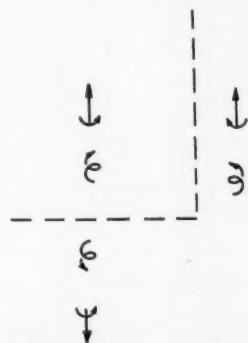


Fig. 7. A spiral and its mirror images. The horizontal mirror changes the direction but not the sense of rotation. The vertical one changes the sense of rotation, but not the direction.

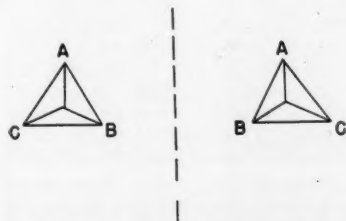


Fig. 8. An asymmetric tetrahedral molecule viewed in a mirror.

COBALT - BETA-DECAY

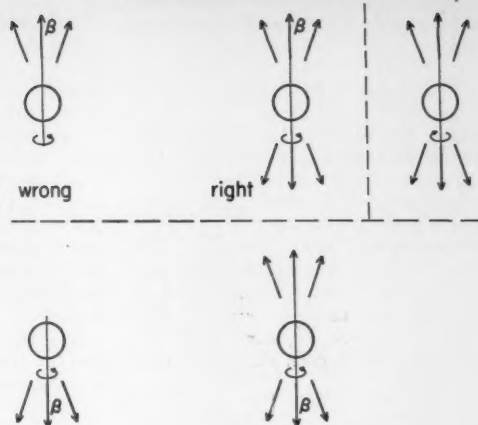


Fig. 9. Cobalt beta decay. Possible electron decay patterns and their mirror images. Only the choice which is mirror-symmetric should occur if the principle of parity is valid.

but the direction of the electrons is reversed. Thus the situation marked “wrong,” in which more electrons emerge in one direction than in the other, violates the principle of parity: the mirror image contradicts the actual situation. Since the parity principle requires both to be right, we must exclude this case. Hence, we expect the same number of electrons to emerge in each direction.

This now sets the scene for the experiment. It was performed at the National Bureau of Standards in Washington, D.C., where the cryogenic equipment was available for experimenting at very low temperatures. The physicists who did it were C. S. Wu from Columbia University and E. Ambler, R. W. Hayward, D. D. Hoppes, and R. P. Hudson of the National Bureau of Standards. They oriented the rotation of cobalt nuclei and compared the electron intensities in the two opposite directions along the axis of rotation.

There are several remarkable features about this experiment. It is one of those experiments which only a few people would perform because the result “obviously” follows from mirror symmetry. Great discoveries are always made when one doubts the “obvious.” In this case, it was the insistence of two theoretical physicists, T. D. Lee of Columbia and C. N. Yang of the Institute for Advanced Study, which prompted the experimenters to look for the effect. Lee and Yang suspected that the principle of parity may be invalid for certain weak interactions like beta decay.

Another remarkable feature of this experiment is the size of the effect which was measured. The intensity of electrons in one direction along the axis of rotation was found to be 40 percent larger than it was in the other. It is very rare in the history of physics that the failure of an established principle shows up with

such large effects in the first experiment. Usually the first doubts are based on small deviations which hardly exceed the limits of error, and only after the passing of time and the application of great effort by many people are effects as large as 40 percent found.

In view of the historic importance of this experiment, it is perhaps worth while to show the actual curves as measured. They are reproduced in Fig. 10. The scale labeled “time” is actually a scale of temperature. The cobalt sample is cooled to a temperature at which its nuclei are aligned, and then it slowly warms up in the course of time. The curve labeled “gamma anisotropy” really tells us the fraction of nuclei which are oriented. For a large anisotropy, most of the nuclei are aligned. As the cobalt warms up, the heat motion causes the alignment to become more random, and the gamma anisotropy decreases.

The curve labeled “ β -asymmetry” is the significant one. This tells us the number of electrons emerging in the direction of the magnetic field, and the number emerging in the opposite direction. We see that there are more in one direction than in the other, that the electrons go up when the spin is turning one way and down when the spin is turning the other way. This shows that the principle of parity does not hold in this experiment. Remember that the spin of the nucleus tells only a sense of rotation. And yet the electron emerges in a preferred direction. This is the mark of the parity violation. The fact that there is a direction associated with a sense of rotation shows that there is a definite “handedness” exhibited in the beta decay of cobalt-60. The mirror image of the decaying cobalt nucleus would have the opposite handedness and seemingly does not occur in nature.

The same experiment has also been

done with cobalt-58, which is a *positron* emitter. It goes over into iron-58 and emits a positron (e^+) and an antineutrino



where $\bar{\nu}$ denotes the antineutrino. Whenever a negative electron is emitted in a beta decay, as in cobalt-60, it is accompanied by a neutrino, and whenever a positron is emitted, it goes with an antineutrino. Most significantly, the same group of physicists have found the opposite handedness in the positron case. For the same rotational sense of the nucleus, negative electrons seem to emerge in one direction and positrons in the other.

Spirality

A possible explanation of these new phenomena has been proposed by Lee and Yang, and independently by L. Landau in Moscow and by A. Salam in England. They suggest that the spirality is associated with the neutrino, since all other phenomena in nuclear physics, which involve no neutrinos, exhibit perfect mirror symmetry. With this hypothesis, the difficulty is isolated from the rest of physics. It "minimizes the damage" and puts this strange property on the neutrino, which is already a strange particle.

Lee, Yang, Landau, and Salam argue that the neutrino is a spiral. Its sense of rotation and its direction of propaga-

tion are connected such that they form, say, a left-handed screw. The neutrino has the property that its spin (its rotation) must be such that its axis is parallel to its motion and its sense such as to form a left-handed screw. The antineutrino is supposed to have the opposite properties. It forms a right-handed screw.

It is interesting to note that particles with such properties must always move with the velocity of light c and, therefore, necessarily have a zero rest mass. If they would move with a velocity v less than c , they would reverse their spirality for an observer moving faster than v in the same direction. Hence, their spirality would be dependent on the observer and could not be an intrinsic property.

With these helical neutrinos, the observed effects can indeed be explained (Fig. 11). The emitted particles must take along some of the spin of the emitting nucleus. Hence, the sense of rotation of the neutrino will be the same as the one of the cobalt nucleus. Its direction of emission must then be such that a left-handed screw is formed. Hence, the neutrino will be emitted only in one direction—namely, the one which forms a left-handed screw with its sense of rotation. The electrons are emitted mostly in the same direction as the neutrino. Thus, we get a preferred direction of emission for the electrons, as observed.

A good support for this explanation is found in the experiment with cobalt-58, in which the emitted particles are a positron and an antineutrino. If the hypothesis is correct, the preferred direction of the positrons must be opposite here to the preferred direction of the electrons in cobalt-60, for the antineutrino has the opposite spirality (I). In fact, that is just what the experiment has shown!

Experiments on Mesons

There is a second kind of experiments in which a similar violation of the parity law has been observed. These experiments have to do with some of the newly discovered short-lived particles, the mesons. The most important meson is the π -meson, which is probably the "quantum" of the nuclear force field. It is responsible for the binding forces in the nucleus. It occurs in three varieties, positive, negative, and neutral; it has a mass 265 times that of an electron, and it is known to have no intrinsic spin. When it is in free motion, the charged π -meson has a very short lifetime (2) of only 10^{-8} second and decays into a μ -meson and a neutrino. The μ -meson is a particle very similar to an electron. It has a charge (positive or negative) and a spin of $\frac{1}{2}\hbar$ just like the electron,

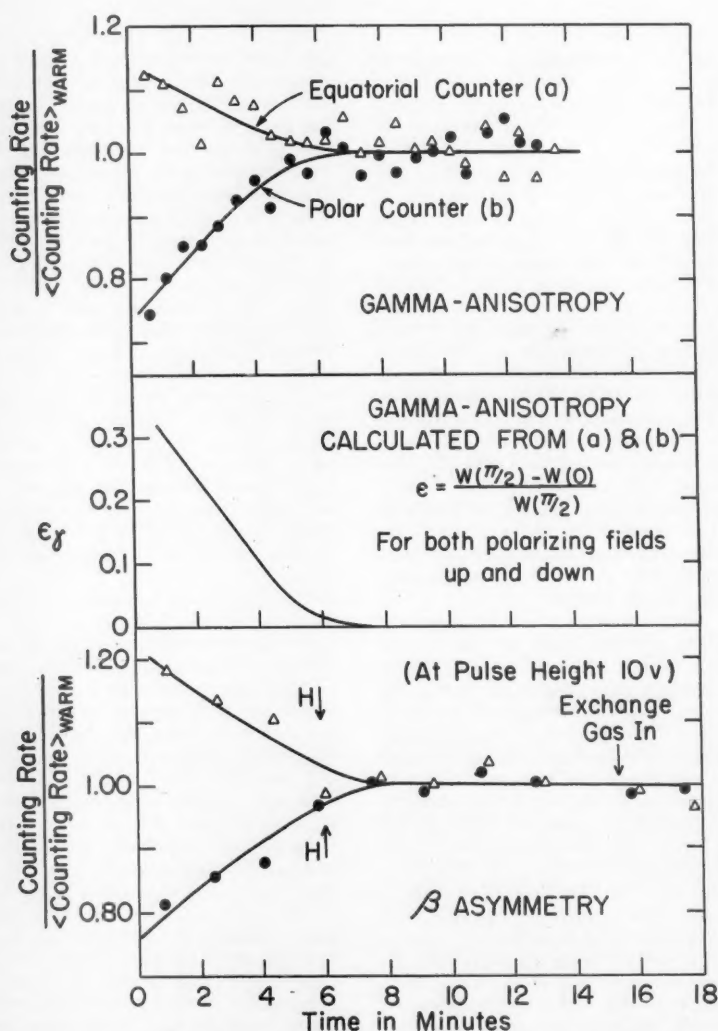


Fig. 10. Experimental observations on β -decay of cobalt-60 (Wu, Ambler, Hayward, Hopes and Hudson). The gamma anisotropy measures the orientation of the nuclei. The β -asymmetry measures the number of electrons which emerge parallel, and antiparallel, to the magnetic field.

COBALT - BETA DECAY

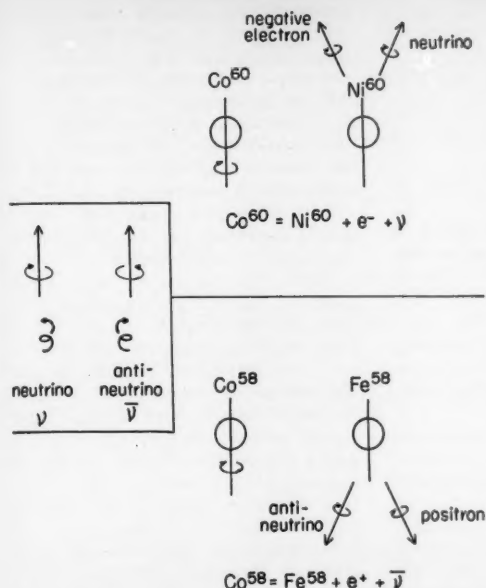


Fig. 11. The Lee-Yang-Landau explanation of the asymmetric beta decay of cobalt-60 and cobalt-58.

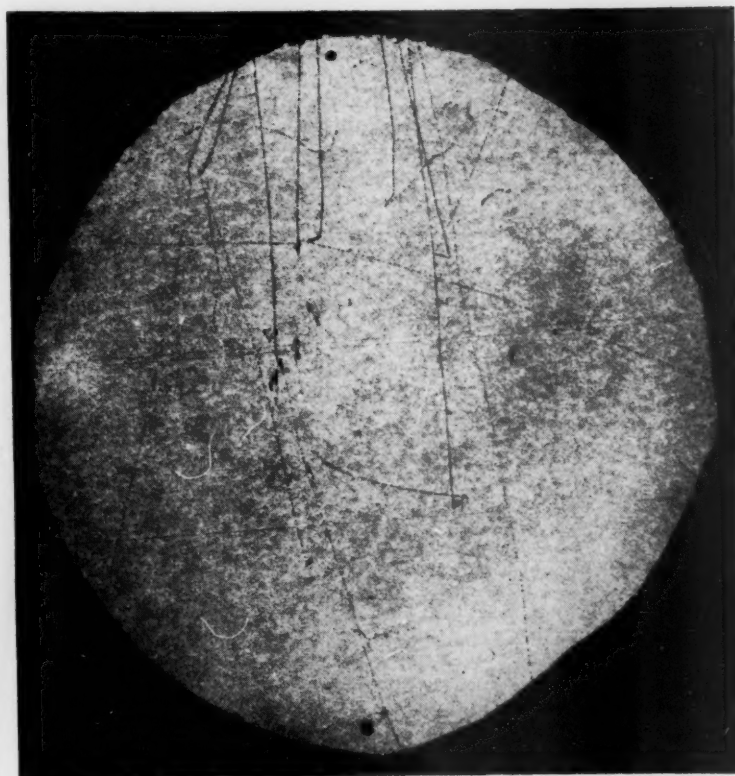


Fig. 12. Bubble chamber photograph of the π - μ - e decay chain (Pless and Williams). Dark tracks entering the chamber from above are π -mesons. Short dark tracks at the ends of the π -meson tracks are μ -mesons produced in the decay of the π -mesons. The long light tracks are electrons produced in the decay of the μ -mesons. The electron tracks emerge in a predominantly-backward direction relative to the direction of the μ -meson tracks.

but its mass is 250 times larger. It too is unstable and decays after 10^{-6} second into an electron and two neutrinos. This double decay chain

$$\pi \rightarrow \mu + \nu \rightarrow e + 2\nu + \bar{\nu}$$

is a very interesting phenomenon and has been studied in detail.

Figure 12 shows a bubble chamber photograph of such processes, made recently by I. Pless, R. Williams, and co-workers. What one sees in such a picture are the charged particles only and not the neutrinos. One observes π -meson tracks coming from above which end when the π -mesons come to rest. They then decay, and one sees a (short) μ -meson track emerge from the end point of the π -meson track. At the end of this track a third track emerges which is the track of the electron. The last track is longer again and is not very straight because the light-weight electron can easily be deviated from its path. A careful observer will find in Fig. 12 that in five out of the six decay chains the electron is emitted "backward" in reference to the motion of the μ -meson. This effect has been established by more careful experiments, at Columbia University by Garwin, Lederman, and Weinrich, at the University of Chicago by Friedman and Telegdi.

Why are the electrons emitted backward? Again, this is an example of the breakdown of the parity rule. When the μ -meson comes to a rest at the end of its short track, the only motion left to it is its rotation. How can a rotation determine a preferential direction of decay? Only by defining a preferential "handedness" or screw sense. This, of course, is a violation of the parity law, for the mirror image of the process would show the opposite preference.

The Yang-Lee hypothesis, ascribing a spirality only to the neutrino, would also explain these meson experiments. This is shown schematically in Fig. 13. The π -meson decays into a μ -meson and a neutrino. The spin of the neutrino is always supposed to form a left-handed screw with its direction of propagation. From this it follows directly that in this decay the μ -meson also must form a left-handed screw with its rotation and its velocity since the spin and motion of the π -meson before decay were zero, and, consequently, the spin and motion of the two decay particles must be opposed. (In general, the spin of the μ -meson is not fixed relative to its direction of motion; Yang and Lee assume such coupling to be compulsory only for neutrinos. However, in this case its spin axis is parallel to its motion, and its sense of rotation is left handed.)

Now we look at the second decay in the chain, the decay of the μ -meson into two neutrinos and an electron. The con-

servation of momentum requires, for those cases in which the electron obtains large energies, that the two neutrinos be emitted in one direction and the electron in the opposite one. The two neutrinos are necessarily emitted in the direction of the μ -meson motion because of the fact that their sense of rotation will coincide with the one of the μ -meson (conservation of spin) and because of the necessity of forming a left-handed screw. Hence, the electron will be emitted mostly backward, as observed (3).

Novelty of the Phenomenon

Let us now discuss two experiments which in all probability cannot actually be performed. A discussion of them is instructive, however, because it illustrates the essential novelty of the phenomenon.

We first return to the pivoted bar with which we began this discussion. Suppose it is made of cobalt-60, and suppose we rotate it about the axis AA' (Fig. 3). (This example was suggested by E. M. Purcell.) As it rotates, the nuclear spins align themselves and the bar becomes very slightly magnetic. (This is the Barnett effect.) The electrons will then be emitted in a given direction; they will be absorbed in the bar, and one end will contain more energy than the other. (Actually, under normal conditions, this effect is so small that it cannot be observed at all.) Since the theory of relativity tells us that energy and mass are related, one end will be heavier than the other. Then, theoretically at least, the bar will tilt. Thus, a microscopic process

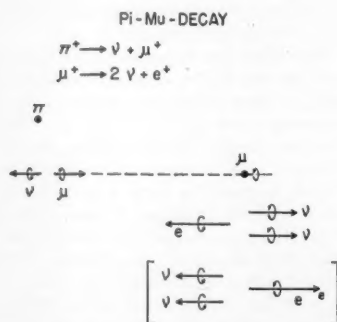


Fig. 13. π - μ - e decay. The neutrino is a spiral (here shown as left-handed). The μ -meson produced in π - μ decay must possess the same spirality. When the μ -meson decays, two neutrinos are emitted in a direction opposite that of a high-energy electron. Because of the inherent spirality of the neutrinos, the relative directions must be as shown. The mirror image of this decay process is shown in brackets. By the parity principle, this should also be a possible decay process; experiment shows that it is not.

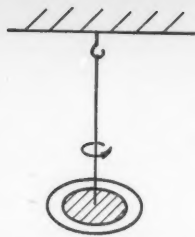


Fig. 14. Aluminum disk suspended by a thin wire. If the disk is coated on top with cobalt-60 it will spontaneously rotate as shown.

(beta decay) which violates the principle of parity could lead in principle to a macroscopic observation of its violation.

An even more dramatic experiment has been suggested by J. R. Zacharias. Suppose a small round disk of aluminum is coated on the top with a thin film of cobalt-60 and suspended in a horizontal position by a thin wire attached to its center, as shown in Fig. 14. The disk will begin to rotate! And, if the experiment is repeated, it will always rotate in the same direction! This can be understood from our previous discussion of beta decay, if we observe that the electrons which are emitted downward will be stopped in the aluminum, while those which are emitted upward will escape (the neutrinos escape in either case). One can think of the electrons which are stopped as transmitting their spirality to the block, which then begins to rotate. If the cobalt coating were on the lower side, the rotation would be in the other direction.

Antimatter

It is very suggestive to consider the violation of the principle of parity in connection with another somewhat better known asymmetry in our physical world. This is the asymmetry with respect to electric charge. The massive atomic nuclei are all positively charged, and the light electrons are negative. Physicists began to suspect that this asymmetry was only apparent after the discovery of the positive electron, the positron, in the early 1930's. It was shown that one can produce an electron pair, a negative and a positive electron, with light quanta of sufficient energy. The positron is in all respects the exact opposite of the negative electron; it is its so-called "antiparticle." If a positron hits an ordinary electron, the two particles annihilate each other (the opposite process of pair creation), and their masses are transformed into light energy. The question of charge symmetry was completely cleared up after the discovery last year of the antiproton and the antineutron. The antiproton is a negative

proton; it is antiparticle to the ordinary proton. It was produced with the very high energies now available from the large accelerators. The antineutron is the antiparticle of the ordinary neutron; it is just as neutral in respect to charge, of course, but it is opposite to the neutron in all respects. For example, it has the opposite magnetic moment, and it will annihilate into γ -rays or other forms of field energy with any neutron it meets, just as the negative proton will when it encounters a positive proton.

Hence, it seems that the charge asymmetry of matter is only apparent. One could also build up "antimatter," as it were, by using antiprotons and antineutrons for nuclei and positrons around them instead of electrons. Such antimatter would be the exact replica of our matter, with opposite charge: negative nuclei and positive electrons. It just so happens that our world is made of one type of matter. Some distant galaxies might be made of the other type.

We do not know much about the properties of antimatter, but it is highly plausible that there exists an interesting reciprocity in respect to the parity problem. We have mentioned that cobalt-58, which is a positron emitter, has shown the opposite spirality to the negatron emitter, cobalt-60. Cobalt-58 emits antineutrinos, which are the antiparticles to the neutrinos emitted by cobalt-60. Hence, antiparticles seem to have the spirality opposite to that of the particles. Thus, it is most probable that "anticobalt-60" would emit its positrons in the opposite direction to cobalt-60. If this is so, the violation of the mirror symmetry appears in a new light: we argued before that the mirror image of cobalt-60 decay does not correspond to any possible process in nature. Now we see that this mirror image might be just the decay of "anticobalt-60"! By bringing together the two asymmetries in nature, the charge asymmetry and the mirror asymmetry, we might be at the threshold of the discovery of a new and higher symmetry, which Landau has called the Combined Parity Principle. This principle says that the mirror image of any process in nature is also a possible process, but only if all charges are replaced by their opposite charges or if matter is replaced by antimatter. Since matter and antimatter are completely equivalent, the mirror symmetry of nature would be re-established in a new and more interesting form.

We have seen in these developments how the increase in our knowledge of the properties of nature sometimes rocks the foundations of our understanding and forces us to a greater awareness of unsolved problems. The more the island of knowledge expands in the sea of ignorance, the larger its boundary to the unknown.

Notes

1. Many authors, in fact the majority, reserve the name "neutrino" for the particle which accompanies the positive β -decay, and call "anti-neutrino" the particle which is emitted in the negative β -decay. This choice is opposite to

ours and would result in giving the neutrino a right-handed spirality. Our choice was done solely for the convenience of introducing the neutrino before the anti-neutrino.

2. The uncharged π -meson has an even shorter lifetime, but it will not be considered here.
3. In order to make this difficult chain of reason-

ing as simple as possible, we have made the assumption that the two neutrinos emitted by the μ -meson are identical. Actually, it seems more probable that they are of different kinds, neutrino and antineutrino. Under these conditions, the same conclusion can be reached, but only in a more subtle way.

Outer Space in Plants

Some Possible Implications of the Concept

Paul J. Kramer

For many years, work on the absorption of ions by plants has been dominated by the assumption that ion accumulation is the important process in ion absorption. For readers who are not familiar with the terminology of this field, these processes may be defined as follows. *Absorption* is a general term referring to the entrance of a substance into cells, tissues, or organs by any mechanism such as diffusion, mass movement, or active transport. *Accumulation* is a special type of absorption involving entrance against a concentration gradient by active transport. *Accumulation* requires the expenditure of metabolic energy by the cells or tissues in which it occurs; other absorption mechanisms do not. *Active transport* refers to movement of substances against a concentration or activity gradient, in contrast to passive movement, by diffusion along an activity or concentration gradient. The mechanism of active transport is not fully understood as yet, although theories involving carrier systems are popular at present (1).

There is increasing evidence that ion accumulation in cells may be a subsidiary process of importance chiefly at the cellular level and that ion absorption and translocation in intact plants occur more or less independently of accumulation. This possibility has been greatly increased by the development of the concept of outer space or apparent free space. By outer space is meant that fraction of the tissue volume into and out of which ions can move freely by diffusion.

Volume and Location

Hope and Stevens (2) seem first to have studied quantitatively this space in roots. They observed that up to 13 per-

cent of the volume of *Vicia faba* roots consisted of space into and out of which ions are free to diffuse and termed it "apparent free space" (often abbreviated AFS). Butler (3) established the existence of free space in wheat roots by several methods and found that it comprised 24.5 to 33.5 percent of the root volume. Epstein (4) found that passive, reversible diffusion of several ions occurs into and out of a space in barley roots that is equivalent to 23 percent of their volume. Following the terminology of Conway and Downey (5), who had previously observed a similar situation in yeast cells, Epstein (4) termed the fraction of the root volume that is reversibly accessible to ions by diffusion "outer space." The fraction of the tissue in which ions are accumulated by an active transport system was termed "inner space." The existence of space in cells accessible to various solutes by diffusion has also been observed in bacteria (6), in yeast (5), and in kidney tissue (7).

Although Epstein did not identify outer space with any particular region of cells, Hope and Stevens (2) and Butler (3) assumed that it included both cell walls and cytoplasm. It would be difficult to account of the volume of outer space observed in roots by various workers without including at least part of the cytoplasm. This means that the differentially permeable membrane which controls accumulation of ions is the tonoplast or vacuolar membrane rather than the outer surface of the protoplast or plasmalemma, as is often supposed.

That diffusion of ions into the cytoplasm occurs is indicated also by other types of experiments such as those of Brooks (8), Hoagland and Broyer (9), and Sutcliffe (10). Hope and Robertson (11), after reviewing previous work,

concluded that the vacuolar membrane, rather than the plasmalemma, is the principal membrane in cells that is impermeable to solutes. Thus, inclusion of at least a part of the cytoplasm in outer space seems highly probable, although it has not been proved. Some binding of ions occurs in the cytoplasm, and apparently mitochondria accumulate ions and ought therefore to be excluded from outer space.

Thus far outer space has been discussed only in connection with the absorption of ions by roots, but if it occurs in roots it almost certainly also occurs in stems, leaves, and other plant structures. Perhaps practically all of the water-permeable structure of plants can be regarded as outer space, except the vacuoles, mitochondria, and ion-binding sites in the cytoplasm. Intercellular spaces are not included, because they ordinarily are occupied by air. Regardless of exactly what is included in outer space, the existence of a considerable volume in plant tissues into and out of which ions can diffuse freely must have important effects on other plant processes besides salt absorption.

Aids in Explaining Diverse Phenomena

The concept of outer space makes it possible to explain a number of phenomena which are difficult to explain if it is assumed that most of the ions in plants move from vacuole to vacuole by active transport, or are accumulated in vacuoles behind differentially permeable membranes. Examples are the increased absorption of minerals accompanying the increased absorption of water, the wide variety of ions found in plants, the absorption of large molecules such as chelates and antibiotics, and the leaching of ions from leaves by rain.

Outer space provides a pathway by which ions may move from the soil solution to the leaves without passing through the vacuole of a single cell. Furthermore, according to this concept, a considerable fraction of the salt, and perhaps of other solutes, is not irreversibly accumulated in vacuoles, but occurs in outer space where it can move freely by diffusion, aided by cytoplasmic streaming, or can be carried by mass flow. All movement of materials in the xylem and probably

The author is James B. Duke professor of botany at Duke University, Durham, N.C.

all movement in the phloem can be regarded as occurring in outer space. Movement of materials through the symplast, as proposed by Arisz (12) also might be regarded as occurring in outer space.

It is much more reasonable to suppose that ions move across the cortical cells of roots by diffusion, aided by cytoplasmic streaming, or are carried by mass flow in the transpiration stream, than to suppose that they are successively accumulated and released by each of the numerous cells through which they must pass. Arisz (12) and Epstein (4) have pointed out that it is difficult to understand how each of the several cells of the root cortex can accumulate ions on the outer side and lose them on the inner side, until finally the ions are secreted into the xylem. The energy requirements for such movement from vacuole to vacuole would be extremely high. Broyer (13) found some evidence that in roots that are high in salt content, movement of ions may occur through the symplast without their entering cell vacuoles, and Wiebe and Kramer (14) found that absorption of ions and translocation to the shoots of intact plants seem to occur independently of accumulation.

Scott and Priestley (15) long ago suggested that the soil solution diffuses into the root cortex and that ions are absorbed from this solution by the cortical cells. They believed that diffusion beyond the cortical parenchyma was prevented by the suberized radial walls of the endodermis, but if ions can diffuse through the cytoplasm, then the endodermis is not the important barrier it formerly was supposed to be. Furthermore, much of the water and salt absorption of perennial plants probably occurs through roots in which secondary growth has resulted in the disappearance of the endodermis.

The existence of a considerable percentage of the root volume as space in which ions are free to move by diffusion or mass movement explains why increased uptake of water often results in increased uptake of salt. Obviously ions in outer space would tend to be moved more rapidly into the xylem by more rapid inward movement of water. How much of this movement occurs through the cell walls and how much through the cytoplasm is uncertain. Strigger (16) has long insisted that considerable movement of water and solutes occurs in the cell walls. This may be true, but the marked reduction in both water and ion movement which occurs in the presence of respiration inhibitors (17) suggests that at some point water and ions pass through protoplasm. In young roots this may be chiefly at the endodermis, and in older roots where the endodermis has

disappeared it probably is at the cambium.

The concept of outer space aids in explaining ion uptake by transpiring plants, but it increases the difficulty of explaining how ions are accumulated in the xylem elements of slowly transpiring plants in sufficient concentration to cause the occurrence of root pressure. The Crafts-Broyer (18) theory of accumulation depends on accumulation in the cytoplasm of the surface cells and movement into the stele by diffusion aided by cytoplasmic streaming. This system cannot operate if ions can diffuse in and out of the cytoplasm, as must be the case if cytoplasm is included in outer space. At present there seems to be no satisfactory way of explaining salt accumulation in the xylem.

The concept of outer space is very useful in explaining why plants contain almost every ion found in their environment, although individual cells are highly selective with respect to the ions accumulated in their inner space. All of the solutes in the soil solution probably are carried throughout plants in the transpiration stream and occur in the outer space of roots, stems, and leaves, but the various ions are accumulated in the inner space or cell vacuoles in quite different proportions from those occurring in outer space; hence, the total amounts of various elements present vary widely in different species. Apparently, because it occurs through outer space, absorption is much less selective than accumulation, while accumulation is brought about by an active transport system that operates only on certain ions and therefore is highly selective.

Movement of solutes in free space probably also explains the absorption of large molecules such as those of iron chelates (19). It is very unlikely that such large molecules are accumulated in cell vacuoles, but it is quite possible that they move through outer space. Apparently, at least part of the movement of antibiotics also occurs in outer space. Crowdy *et al.* (20) reported that the uptake of griseofulvin by broad beans and tomatoes is proportional to the volume of water transpired by the plants.

The concept of outer space in roots as the chief pathway for entrance of ions requires less emphasis on the ion-exchange properties of root surfaces and soil particles. If it is assumed that the soil solution actually diffuses into the root, then ion-exchange properties of the soil are important only insofar as they affect the composition of the soil solution. The factors affecting absorption and accumulation operate at the surfaces of or within the cells of the roots, rather than at the outer surfaces of the roots, as often has been supposed.

Leaching

The assumption that a considerable amount of the salt in leaves occurs in a diffusible condition in outer space facilitates the explanation of losses of solutes from leaves by leaching. It has been reported by several workers (21, 22) that considerable amounts of salt are leached from leaves by rain, sprinkling, or brief soaking in water. It is difficult to understand how this could occur if most of the salt were accumulated within impermeable membranes, but it is obvious that solutes occurring in a freely diffusible state in outer space can be leached out very easily. Apparently, some organic compounds can be leached out also, for Long *et al.* (22) found that several amino acids and large quantities of a galactan were leached out of leaves. It also has been suggested that excessive loss of carbohydrates by leaching might explain some instances of heavy losses of newly set fruit during prolonged rainy periods.

Ions moved to the leaves in the transpiration stream presumably occur chiefly in outer space, from which they are accumulated in the vacuoles of the leaf cells. If transpiration is rapid, there may be a tendency toward salt accumulation in the outer space of leaves, and there is some evidence that rapidly transpiring leaves often contain more salt than slowly transpiring leaves (23), but ordinarily the concentration does not become very high, because of removal by leaching and by retranslocation out of the leaves through the phloem. According to this view, the cells of the leaves accumulate ions in their inner space from outer space in the same manner that root cells accumulate ions from the soil solution that occurs in their outer space.

It is probable that outer space also plays an important part in the absorption and movement of solutes applied to the leaf surface, such as foliar sprays. It is unlikely that such solutes are first accumulated in the inner space of cells, then released and translocated to other parts of the plant. It is much more probable that the solutes diffuse into the aqueous phase of outer space and are then either moved out through the phloem or accumulated.

The presence of an appreciable fraction of the total volume of plants in which ions are free to move by diffusion raises questions concerning the methods used in analytic studies. For example, roots usually are rinsed thoroughly in water before the uptake of ions is determined by either chemical or radiochemical methods, but such washing obviously removes a large part of those ions that occur in outer space. Epstein (4) found

that SO_4^{--} , PO_4^{--} , SeO_4^{--} , and Ca^{++} were easily washed from outer space, and Russell and Adams (24) found that considerable phosphate was removed from barley roots by washing prior to analysis.

Leaves often are washed to remove dust from their surfaces, but this may also remove considerable amounts of various solutes. Although Hammar (25) found that washing did not materially affect the chemical composition of pecan leaves, the results of leaching studies on other species suggest that considerable salt and even organic solutes might be removed by washing. This increases the difficulty of dealing with roots covered with soil and leaves covered with dust or spray residue, but the probability of significant leaching during washing cannot be evaded. Britten (26) recently reported that proline is washed out of *Escherichia coli* cells by washing in water or a dilute solution.

It would be interesting to know more about the relative physiological importance of the ions and other solutes in outer and inner space. It might be argued that those substances which occur in outer space are in more intimate contact with cytoplasm and are more important physiologically than the larger fraction which is accumulated in the vacuoles. The usual methods of analysis do not distinguish between the fractions in inner and outer space, but methods could be devised to estimate the two fractions. Such information might be more useful in studies of translocation and plant nutrition than information concerning the total amount of an element present in a plant.

Need for Correlation of Research

Failure of previous investigators to apply the concept of outer space to an explanation of the various phenomena discussed in this article illustrates a basic weakness in modern science. Too little attention is being given to the correlation and interpretation of separate pieces of research. Thousands of investigators are collecting data and publishing data, but very few are correlating and interpreting their results. Investigators working with bacteria, yeast, plant roots, and animal tissue have all observed similar phenomena, but little attempt has been made to draw any general conclusions from these observations. The investigators who first developed the concept of outer space in roots thought of it only in terms of salt absorption in roots, while the workers studying salt absorption through leaves, leaching of solutes out of leaves, or the relation between water and salt absorption were so concerned with their own particular problems that they failed to see the relationship between their work and that of other investigators. As a result, the broad implications of the concept of outer space have been overlooked by most physiologists.

It is possible that further research will result in revision of the rather simple concept of outer space or free space which is now held. Its potential importance in explaining several different phenomena certainly justifies additional research to gain a better understanding of it. If outer space occupies as large a volume in plants as now seems probable, considerable revision of our present ex-

planations of ion absorption and translocation may be necessary.

References and Notes

1. P. J. Kramer, *Handbuch der Pflanzenphysiologie* (Springer, Berlin, 1956), vol. 2, p. 290.
2. A. B. Hope and P. G. Stevens, *Australian J. Sci. Research B5*, 335 (1952).
3. G. W. Butler, *Physiol. Plantarum* 6, 617 (1953).
4. E. Epstein, *Plant Physiol.* 30, 529 (1955).
5. E. J. Conway and M. Downey, *Biochem. J. (London)* 47, 347 (1950).
6. D. B. Cowie et al., *J. Cellular Comp. Physiol.* 34, 243 (1949); R. B. Roberts et al., *Carnegie Inst. Wash. Publ. No.* 607 (1955).
7. R. Whittam and R. E. Davies, *Biochem. J. (London)* 56, 445 (1954).
8. S. C. Brooks, *Cold Spring Harbor Symposia Quant. Biol.* 8, 171 (1940); *Protoplasma* 42, 63 (1953).
9. D. R. Hoagland and T. C. Broyer, *J. Gen. Physiol.* 25, 865 (1942).
10. J. F. Sutcliffe, *J. Exptl. Bot.* 5, 313 (1954).
11. A. B. Hope and R. N. Robertson, *Australian J. Sci.* 15, 197 (1953).
12. W. H. Arisz, *Protoplasma* 46, 1 (1956).
13. T. C. Broyer, *Plant Physiol.* 25, 367 (1950).
14. H. H. Wiebe and P. J. Kramer, *ibid.* 29, 342 (1954).
15. L. Scott and J. H. Priestley, *New Phytologist* 27, 125 (1928).
16. S. Strügger, *Praktikum der Zell- und Gewebephysiologie der Pflanzen* (Springer, Berlin, 1949).
17. R. Brouwer, *Acta Botan. Neerl.* 3, 264 (1954).
18. A. S. Crafts and T. C. Broyer, *Am. J. Bot.* 35, 529 (1938).
19. C. D. Leonard and I. Stewart, *Proc. Am. Soc. Hort. Sci.* 62, 103 (1953).
20. S. H. Crowdy et al., *J. Exptl. Bot.* 7, 42 (1956).
21. K. Arens, *Jahrb. wiss. Bot.* 80, 249 (1934); J. A. LeClerc and J. F. Breazeale, *Yearbook Agr. U.S. Dept. Agr.* (1938), p. 389; K. Schoch, *Ber. Schweiz. botan. Ges.* 65, 205 (1955); M. G. Mes, *S. African J. Sci.* 50, 167 (1954); G. M. Will, *Nature* 176, 1180 (1955).
22. W. G. Long et al., *Science* 123, 1039 (1956).
23. J. G. Kisser, *Handbuch der Pflanzenphysiologie* (Springer, Berlin, 1956), vol. 3, p. 669.
24. R. S. Russell and S. N. Adams, *Plant and Soil* 3, 223 (1954).
25. H. E. Hammar, *Plant Physiol.* 31, 256 (1956).
26. R. J. Britten, *Science* 124, 935 (1956).

A. S. Pearse, Ecologist

Arthur Sperry Pearse, emeritus professor of zoology at Duke University, died 11 December 1956 in Durham, North Carolina, at the age of 79 years. He was born 15 March 1877, on the Pawnee Indian Reservation near Crete, Nebraska, where his father and mother managed a trading post. His boyhood was spent there and in Denver, Colo-

rado. In growing up he experienced many colorful adventures in the rough life of the western mining camps and pioneer farms of the period, and throughout his life he, like Theodore Roosevelt, was an ardent exponent of the strenuous life.

From the very beginning he was intensely interested in natural history, and

it is not surprising that he became an ecologist. He began collecting in these early years. In his autobiography, *Adventure: Trying To Be a Zoologist*, he writes, "As a boy I loved animals and everything concerning them. I was born to be a zoologist." Many events and many people were to influence his career. While attending high school at Beatrice, Nebraska, he studied chemistry and physics under Samuel Avery, who later became president of the University of Nebraska.

At the University of Nebraska he played football—the beginning of a lifelong love of athletics. Characteristically, he left the university in 1898 to serve as corporal with the 4th Nebraska Volunteer Infantry in the Spanish-American War, returning to receive the bachelor of science degree in 1900. While teaching high school at Omaha he worked for his master's degree under the direction

of his old professor at Nebraska, H. B. Ward, who gave him his fundamental training in parasitology. In 1941, the University of Nebraska conferred an honorary LL.D. degree on this distinguished alumnus.

After receiving his Ph.D. degree at Harvard University in 1908, under George H. Parker's guidance, Pearse began an active career in parasitology and ecology. These fields of investigation carried him from the shores of Lake Michigan and Lake Mendota in Wisconsin to the Philippines, to the rain forests of Colombia and Venezuela in South America, to the cenotes and caves of Yucatan, to the Dry Tortugas, on to Japan, China, Siam, and India, and to England and Nigeria. In 1929-30 he was visiting professor at Keio University in Japan. From these experiences came his volume, *Hell's Bells*, a reflection of his philosophy and his wide interest in the life of the peoples among whom he visited.

At the University of Michigan there developed the beginnings of his lifelong friendship with Alexander G. Ruthven, who later became president of the university and with whom he made a scientific expedition to Colombia. An ecologist at Wisconsin during a portion of the lengthy Birge and Juday era of lake studies, Pearse, too, contributed extensively to the biology of fresh-water fauna. As a special member of the field staff of the International Health Board of the Rockefeller Foundation, he studied the incidence of hookworm infection in Alabama in 1925, and the next year, in Nigeria, was ecologist on the team of scientists that established the fact that yellow fever was not carried by spirochetes, as had been previously suggested by Noguchi. Pearse's early affiliation, for three seasons, with the invertebrate zoology class at the Woods Hole Marine Biological Laboratory acquainted him with marine life and furnished the background for much of his later research on the ecology of marine fauna, a field in which he made perhaps his greatest contribution.

While Pearse was teaching in the zoology department of Duke University, his interest in marine biology led to the

founding of the Duke University Marine Laboratory at Beaufort, North Carolina, in 1938. The station, in its present state of development, has largely followed the plans he originally envisioned. Pearse served as director of the station for 10 years.

His publications, numbering about 175, were not limited to a narrow field of specialization. A dynamic worker, he was readily able to adjust himself to new conditions, so that, wherever he was, he quickly found research interests. Inland, in lake country, he studied fresh-water fauna; at the seashore, he concentrated on beach and estuarine animals; on the Duke campus, stimulated by the proximity of the Duke Forest, he investigated the fauna of soil and forest environments. An expert on Crustacea, he published numerous papers on parasitic crustaceans and described many new species of copepods parasitic on marine fishes. His studies of animals living in association with one another led to coinage of the term *consortes* to cover the numerous conditions found in the ocean where the nature of the inter-relationship, whether symbiotic, commensal, or parasitic, was not clear. An underlying theme of much of his work in marine ecology was the migration of animals from sea to land. This idea was ever before him as he traveled in various parts of the world. His book, *Emigrations of Animals from the Sea*, summarizes much of this research and shows his originality of thought. Among other books written by him is his *Animal Ecology*, one of the few important textbooks in that field in his day. This book demonstrates the depth of his knowledge of animal associations. Pearse founded *Ecological Monographs* and found time to be its editor from 1930 to 1950.

His early efforts to educate himself, in Beatrice, at the University of Nebraska, and later at Harvard University, gave him an understanding and love of students which continued all his life. In the teaching positions he successively held at Harvard University, the University of Michigan, the University of the Philippines, St. Louis University Medical School, and the University of Wisconsin, and as chairman of the de-

partment of zoology at Duke University, he always insisted that the welfare of the students came first. Although he was reported by a faculty colleague to violate every known rule of pedagogy, he always had an enthusiastic following of both graduate and undergraduate students. He especially liked to teach freshmen, with whom he said "one could do much before they were contaminated by college life." His graduate students will remember the genial hospitality of his house, where, with his wife and children, he entertained a great many of them. He instilled his love of field work in his students and never let them be daunted by high winds, torrential rains, or other minor discomforts. Brusque and brief, always ahead of schedule, he sometimes overawed them until they came to understand his informality and kindness. Generous as he was to organized charities, he was even more generous to those he knew to be in need. Stories cluster about his name, making him an almost legendary character in the various places he lived.

Pearse was a member of many scientific societies and served as president of the Ecological Society of America (1925), American Society of Zoologists (1945), Association of Southeastern Biologists (1942), and North Carolina Academy of Science (1951) and as vice president of the American Association for the Advancement of Science, Section F (1936).

His influence contributed in no small measure to the development of modern scientific scholarship at Duke University. Among the first group of graduate professors to be appointed, he helped to organize the University Research Council and was its first secretary. His aim was always to promote more effective teaching, research, and scholarship. As he gratefully acknowledged his debt to his teachers and associates in zoology, so, too, his many students will continue to credit him with the inspiration which he so notably contributed to their lives and their research. He left an indelible mark on all who knew him.

I. E. GRAY

Department of Zoology, Duke University, Durham, North Carolina



News of Science

Tatum Named to Editorial Board

It is a pleasure to announce that Edward L. Tatum was appointed to the editorial board of *Science* and *The Scientific Monthly* on 1 Apr. Tatum, now 47 years old, took his A.B. degree in chemistry, his master's degree in microbiology, and his Ph.D. degree in biochemistry at the University of Wisconsin, thus getting a strong background in several sciences.

Following a year as research assistant in biochemistry at Wisconsin (1934-35) and a year as a fellow of the General Education Board at Utrecht (1936-37), Tatum joined the Stanford University biology department, where he was a research associate (1937-41) and an assistant professor (1942-45). After having served on the Yale University faculty, first as associate professor of botany (1945-46) and then as professor of microbiology (1946-48), he returned to Stanford as professor of biology. He held this post until he became a member of the Rockefeller Institute for Medical Research in January of this year.

Tatum has served many national scientific bodies, and at present, in addition to being on the National Science Board, he is a member of the Committee on Virus Research and Epidemiology, National Foundation for Infantile Paralysis; the Biology Council, National Research Council; Biology Panel, National Science Foundation; and the Research Advisory Council, American Cancer Society. His honors include the American

Chemical Society's Remsen award, selection as the Herter lecturer at New York University, and membership in the National Academy of Sciences.

His special interests have been the nutrition and metabolism of insects and microorganisms and the biochemistry and genetics of microorganisms. Some of his most significant research results are as follows: identification of thiamine as a growth factor for propionic acid bacteria; isolation and identification of kynurenine as an eye-color hormone in *Drosophila* (with G. W. Beadle); discovery of biochemical mutants in *Drosophila* (with G. W. Beadle); biochemical mutations in bacteria; gene recombinations in *Escherichia coli* (with J. S. Lederberg); biosynthesis of tryptophan (with D. M. Bonner).

Tatum's wide-ranging scientific interests, outstanding research accomplishments, and diverse academic experience make him notably well qualified to serve as a member of the editorial board of *Science* and *The Scientific Monthly*. In addition, his experience since 1948 as a member of the editorial board of the *Journal of Biological Chemistry* and as assistant managing editor of the *Annual Reviews* (1948-53) should serve him well in his new post. We welcome Tatum as a distinguished new member of our editorial board.—G. DuS.

South Atlantic IGY Studies

The program to study the deep water masses of the South Atlantic Ocean during the International Geophysical Year got under way in February when the research vessel *Crawford*, which belongs to the Woods Hole Oceanographic Institution, left Woods Hole, Mass. The 125-foot vessel will have crossed the Atlantic four times and covered some 18,000 miles by the time it returns next June.

F. C. Fuglister, oceanographer and chief scientist on board the ship, has explained that the main objective of the cruise is to determine what changes may have taken place in the physical and chemical properties of the water masses of the South Atlantic Ocean since the classic survey made by the German oceanographic ship *Meteor* during the years

1925-27. The *Crawford* carries a scientific complement of six and 15 officers and crew members.

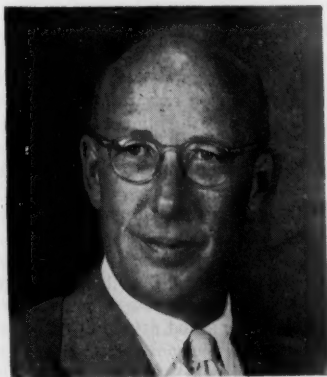
The horizontal and vertical movements of the ocean water masses influence the climate of the world. An understanding of this circulation, of which we are still largely ignorant, may lead to forecasts of climatic changes, similar to the many wild or severe fluctuations which have taken place since the last ice-age.

Many hundreds of temperature and salinity observations from the surface to near the bottom are being made by the *Crawford's* investigators, who work regular ships hours. Water samples are titrated for salinity and for oxygen content. Formerly water samples for salinity titration were brought back to Woods Hole for analysis. An electronic salinometer, designed by Karl E. Schleicher of the Woods Hole Oceanographic Institution, now makes it possible to obtain the desired data on board ship.

If the ocean is to be used as a disposal area of atomic waste products, it is necessary to know soon where and how such disposal can safely take place. We know that the ocean is slowly "turning over." How long does it take for the surface water to sink to the bottom? Estimates based on several methods and extensive research during the last few years differ widely from a time range of about 150 years to 1000 years and more. L. V. Worthington of the Woods Hole Oceanographic Institution has suggested that the cold bottom water of the North Atlantic Ocean formed during the little "ice-age" about 150 years ago. Pollution from atomic waste, unlike the familiar harbor pollution, is irremediable. It is therefore essential to learn more about the deep water movement of the ocean.

For the moment, fission products, deposited in the ocean by fall-out from nuclear weapons tests, are an aid to oceanographic studies. The introduced fall-out materials can be measured and form an excellent tracer to study the horizontal diffusion in the sea and the rate of mixing between different water layers. On board the *Crawford* a 55 gallon plastic water sampler designed by Vaughan T. Bowen, geochemist, is lowered to various depths to obtain large water samples. The samples are acidified on board the *Crawford*; the carbon dioxide is driven off and collected chemically for analysis of its content of radioactive carbon-14 and stable carbons 12 and 13. The carbon-14 dating techniques have been used before to determine the age of sea water, but more studies need to be made. This is the first time that such samples have been collected in conjunction with a hydrographic survey of temperatures and salinity and on complete transverse sections across the ocean.

After the carbon-dioxide has been re-



Edward L. Tatum

moved, 15-gallon polyethylene drums, with steel outpack, will be filled for return to Woods Hole, Mass., by freighter from the *Crawford's* ports of call. The small vessel cannot stand the additional deckload of 88 filled drums. These samples will later be analyzed for many radioactive elements, such as strontium-90, antimony-125, cerium-144, promethium-147, possibly cesium-137, and the naturally occurring tritium. Some analyses for stable rare earths will also be made. An idea of the size and importance of this program may be obtained from the list of organizations cooperating in this study. The National Science Foundation and the Office of Naval Research have aided with financial grants, while samples will be analyzed at Woods Hole, at Yale University, the Swedish radioactive dating laboratory at Stockholm, and at Clark University.

Although the physical and chemical observations are the main object of the cruise, the *Crawford* is making a continuous trace of the ocean bottom on the Woods Hole precision echo-sounding recorder. This instrument measures the depth of the ocean with an accuracy of one part in 10,000. In addition, biological observations are being carried out, particularly of whales and porpoises, and sea and land birds are identified and recorded. Further, lines are being towed for pelagic fishes such as tuna, wahoo, and so forth.

The ship is also continuing the usual shark-catching program. Much has been learned during recent years about the activities and natural history of the white-tipped shark, the most common open-sea shark in the North Atlantic and in the Caribbean Sea. At night, an underwater light is hung just below the surface which usually attracts a glittering array of small sea-life, particularly larvae and young stages of fishes and the many deep-sea fishes that come to the surface at night.

Fulbright and Smith-Mundt Awards

The application deadline is 25 Apr. for 1958-59 awards under the Fulbright Act for university lecturing and advanced research in Argentina, Australia, Burma, Chile, Colombia, Ecuador, India, New Zealand, Pakistan, Peru, the Philippines, Thailand, Argentina, Israel, and Turkey.

Programs for Austria, Belgium and Luxembourg, Denmark, Finland, France, Germany, Greece, Israel, Italy, Japan, the Netherlands, Norway, Turkey, and the United Kingdom and Colonial Dependencies will be announced in June, although applications will be accepted from 1 May through the closing date, 1 Oct. 1957.

Grants for lecturing abroad under the Smith-Mundt Act will be available in

approximately 40 countries which do not participate in the program under the Fulbright Act. These countries are in Latin America, the Near East and Africa, the Far East, and Europe. Application forms and additional information may be obtained from the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Ave., NW, Washington 25, D.C.

Markle Scholars

The John and Mary R. Markle Foundation has announced the appointment of 25 scholars in medical science, all faculty members of medical schools in the United States and Canada. The sum of \$750,000 was appropriated toward their support to the schools where they will teach and carry on research.

With these appointments the fund completes 10 years of a program to aid young medical-school faculty members seeking careers in teaching and research. In the decade, 206 doctors in 74 medical schools in the United States and Canada have received help from appropriations totaling \$6,070,000. For each scholar appointed, the fund has allocated \$30,000 granted at the rate of \$6000 annually for 5 years to their medical schools.

The program will continue as a major interest of the foundation. Of those appointed in the 10 years, two have become heads of departments, one directs an important cancer research institute, and two head research divisions in Government laboratories. Twenty-five are full professors and 51 associate professors.

This year's Markle scholars are Richard H. Adler, associate, University of Buffalo School of Medicine, thoracic surgery; Aurele Beaulnes, assistant professor, University of Montreal Faculty of Medicine, pharmacology; Robert E. Carter, instructor, University of Chicago Division of the Biological Sciences, general pediatrics; Sanford I. Cohen, instructor, Duke University School of Medicine, psychiatry (at present medical officer, U.S. Air Force, Wright Patterson Air Force Base); John E. Connolly, instructor, Stanford University School of Medicine, surgery; Frank Falkner, assistant professor, University of Louisville School of Medicine, pediatrics; Lawrence R. Freedman, instructor, Yale University School of Medicine, internal medicine; Thomas R. Hendrix, instructor, after 1 July, Johns Hopkins University School of Medicine, internal medicine (at present research fellow, Evans Memorial-Massachusetts Memorial Hospitals and assistant in medicine, Boston University); David S. Howell,

assistant professor, University of Miami School of Medicine, internal medicine; T. R. Johns, assistant professor, University of Virginia School of Medicine, neurology; Kermit E. Krantz, assistant professor, University of Arkansas School of Medicine, obstetrics and gynecology; Lloyd D. MacLean, instructor, University of Minnesota Medical School, surgery; James A. Merrill, instructor, University of California School of Medicine (San Francisco), obstetrics and gynecology; Robert O. Morgen, demonstrator, McGill University Faculty of Medicine, internal medicine; George C. Morris, Jr., instructor, Baylor University College of Medicine, surgery; Arno G. Motulsky, assistant professor, University of Washington School of Medicine (Seattle), internal medicine; Russell M. Nelson, assistant professor, University of Utah College of Medicine, surgery; George Nichols, Jr., associate, Harvard Medical School, internal medicine; Donald E. Pickering, assistant professor, University of Oregon Medical School, pediatrics; Arthur H. Schmale, Jr., instructor, University of Rochester School of Medicine and Dentistry, internal medicine and psychiatry; John D. Thompson, instructor, Louisiana State University School of Medicine, obstetrics and gynecology; Henry O. Wheeler, instructor, Columbia University College of Physicians and Surgeons, internal medicine; Joseph R. Wilder, assistant professor, New York Medical College, general and cardiovascular surgery; T. Franklin Williams, instructor, University of North Carolina School of Medicine, internal and preventive medicine; William J. Williams, assistant professor, University of Pennsylvania School of Medicine, internal medicine.

AEC Reactor Explodes

A critical assembly, known as the "Godiva," which has been in operation at the Los Alamos Scientific Laboratory since August 1951, was severely damaged during an experiment on 12 Feb. Since the experiment was remotely controlled, no one was exposed to radiation. No physical damage was done to the building in which the experiment was being conducted, and radiation contamination has been removed by standard clean-up methods with no appreciable loss of uranium. Damage to the assembly was such that it is considered impractical to repair it.

The Godiva was one of several simple critical assemblies at Los Alamos that are used for developing information on fast-neutron systems and as a source of large quantities of neutrons for instantaneous irradiations, called "prompt bursts." It consisted of an unshielded spherical mass

of uranium-235 about 6¾ inches in diameter. The sphere was made up of three sections which were assembled remotely to produce chain reactions in the performance of experiments.

At the time of the accident the assembly was being used as a source of neutrons for the instantaneous irradiation of uranium-loaded graphite. The purpose of the experiment was to determine the behavior of this material after exposure to a sudden wave of neutrons.

The thermal shock which resulted in the damage was caused by a nuclear power surge considerably higher than the expected power level. One of the characteristics of the assembly was that its power operating levels were self-limiting in that the thermal expansion of the assembly resulting from power surges would cause the chain reaction to stop. In the 12 Feb. experiment the power surged to such a level that the thermal expansion exceeded the strength of the uranium metal.

The uranium-loaded graphite which was being irradiated was enveloped in layers of polyethylene. It is believed that in the course of the remote operations, a malfunction of special test equipment for the temporary experiment shifted the polyethylene-encased graphite closer to the critical assembly than was intended. The shift in position caused the polyethylene to reflect neutrons back into the critical assembly. The reflected neutrons increased the chain reaction, resulting in a sudden increase in heat which produced the thermal shock in the uranium.

Because the Godiva was not especially designed for the heavy demands for prompt-burst service irradiations which have been made on it, another unshielded assembly had already been designed which will accommodate either delayed or prompt critical experiments. The new assembly will have a wider range and additional protective features desirable for repeated prompt-burst operations.

Lederle Medical Student Fellowships

The Lederle Laboratories Division of the American Cyanamid Company has announced that it is making available to medical schools throughout the United States and Canada Lederle medical student research fellowships for the year 1957. These fellowships, in amounts not exceeding \$600 per year for any one person, are intended to relieve in part the financial burden of students who desire to devote their summer vacations to research in the basic (preclinical) medical sciences.

Students who apply for the fellowships must be of good scholastic stand-

ing and must have the consent of the faculty member under whose supervision their research is to be conducted. The selection of students to receive such awards will be made by the dean of the medical school, or by the regularly constituted committee of the faculty charged with such selections. By special permission of the dean or the fellowship committee of the school, the student may carry on his research in another medical school, provided that satisfactory arrangements are previously made with the faculty member of the school and the department in which the work is to be done.

Resistance of Cells to Viruses

A new substance that may shed light on the susceptibility and resistance of cells to viruses has been isolated and identified by Guy T. Barry and Walther F. Goebel of the Rockefeller Institute for Medical Research, New York, who have reported their work in a recent issue of *Nature*. The chemical, colominic acid, was found in a strain of colon bacillus. This is the first time that an acid of this type has been discovered in bacterial cells.

Colominic acid is a new type of acidic carbohydrate. It is quite unlike any carbohydrate previously obtained from bacterial sources in that it is very rich in a substance resembling sialic acid, which has been of special interest in recent years. When combined in its native state with protein and other sugars, the sialic acid-containing complex interferes with the adherence of certain viruses, such as the influenza virus, to living cells.

Merit Scholarship Corporation

The first annual report of the National Merit Scholarship Corporation has just been released, covering the year ending 30 June 1956. The NMSC is, in the words of the report:

"An independent nonprofit organization, combining the largest independently supported scholarship program ever undertaken, together with a mechanism designed to assist business enterprises which are contemplating aid to education.

"The Ford Foundation and the Carnegie Corporation of New York have undertaken to finance the activity for a ten-year period by grants totaling \$2,500,000 for its administrative expenses. For a basic continuing scholarship program the Ford Foundation has appropriated \$10,000,000, payable at the rate of \$1,000,000 a year for ten years, and is prepared to finance additional scholarships up to a total of \$8,000,000 to match

scholarships which may be contributed from industry.

"The major underlying purposes of these grants are twofold: to discover throughout the country the ablest youth and to make it possible for these talented young people to get a college education regardless of their financial situation; and to make it easier for business enterprises and other organizations to contribute effectively to the support of higher education by the scholarship route.

"A further purpose is to provide, in one organization, a single national talent search and an open-ended flexible scholarship program that will reduce wasteful duplication of operation, and will, at the same time, meet the interests and purposes of the donors."

In the first year of operation 58,158 students took the examination. They were selected by school principals from the top 5 percent of their class. In addition to this method of selection, in 1957 any high-school senior may take the scholarship examination by paying a nominal fee of \$1. Some 5078 finalists were selected from the 58,158. Although "every one of these finalists would have been granted a Merit Scholarship had funds been available (they were among the top two percent of the nation's finest high school students)," 556 winners were selected by a special committee.

Merit scholarships are for 4-year programs, available to seniors in all secondary schools, made on a competitive basis, state by state proportionately to the senior-high-school population. The recipient of the award may attend any accredited institution of his choice, and the stipends vary from \$100 up to the full amount of tuition and expenses, depending on the individual's need. In addition, a certificate of merit was awarded to more than 4000 finalists, and a booklet listing their names was sent to all colleges and universities and to scholarship-granting agencies. "In many instances, these certificates of merit winners received offers of scholarships from one or more institutions and have written to say that, in their opinion, these offers were largely due to our award of a certificate of merit."

Funds (up to \$8 million) are available to match, dollar for dollar, any merit scholarship provided from other sources. All the sponsor's investment goes directly to scholarships, and, further, this investment releases a matching sum. The program expenses are borne by NMSC. "The sponsor is relieved of any embarrassments growing out of the selection of students and the selection of institutions, although the sponsor may, if he wishes, select his Merit Scholar from the large group of highly qualified finalists." In addition the sponsors may specify characteristics in which they are inter-

ested: type of curriculum, geographical area, vocational goal, sex, and so forth. During the first year some sponsors specified scholars who proposed to study science or engineering. About 11 percent of the scholarships were restricted to students planning to study science or engineering; more than half of the merit scholars intend to enter such fields.

Sponsors will be given as much publicity as they desire with regard to their individual program and are assured of having their names scrupulously associated with all payments to the scholar and to the college. Some sponsors wish primarily to help the colleges—almost half of the contribution from the sponsor goes to the private college as an unrestricted gift, in the name of the sponsor.

The 1956 annual report provides complete information on the background of participants, institutions attended by merit scholars, distribution of stipends, career choices of scholars, list of corporation sponsors, and so forth. Some 36 firms are already participating in the activities of NMSC and other firms who are interested in helping to provide scholarship funds to worthy students are invited to confer with the National Merit Scholarship Corporation, 1580 Sherman Ave., Evanston, Ill.

Lalor Faculty Awards in Biology

The principal award of the Lalor Foundation for the summer of 1957 is to Olov Lindberg of the Wenner-Gren Institute of Stockholm, Sweden, who has accepted the invitation of the Marine Biological Laboratory at Woods Hole, Mass., to be the senior Lalor fellow there. One Canadian, two Englishmen, one German, and one New Zealander have also received awards for biological research at institutions in the United States; and one Canadian and five United States citizens will be working similarly, part or full time, in other countries.

The other 30 faculty summer biology research awards go to 13 United States citizens who will be working at their home institutions, and 17 who will be carrying out their programs elsewhere in this country. In connection with the latter group, there are 12 research people who have been accepted for work at the Marine Biological Laboratory at Woods Hole, this being the largest number at any one institution.

The appointments cover a wide range of biological interest: there are 14 awards in biochemistry, nine in botany, five in microbiology, and 13 in physiology. The awards total approximately \$49,000.

The appointments to the regular summer research awards all have been to

faculty members at the instructor, assistant professor, or associate professor level. The distribution of appointments shows 16 percent from tax-supported institutions and 84 percent from privately supported universities and colleges. This contrasts with the previous year, when the appointments were nearly evenly divided.

Allergy Fellowships

The American Foundation for Allergic Diseases has announced the availability of three 2-year fellowships in research and clinical allergy. These awards carry a stipend of \$4500 for the first year, \$4750 for the second, and a total of \$750 for laboratory and travel expenses during the 2-year period. The funds for these fellowships have been made available by John D. Rockefeller, Jr., in a grant to the foundation.

It is the hope of the foundation that the recipients will be stimulated to enter the field of research in allergy and will be equipped to teach others. Unlike the usual procedure, the foundation has established single fellowships with three investigators eminently qualified to teach the principles and techniques of scientific method in this field and in institutions where adequate clinical facilities exist. Applicants should apply directly by 10 May to one of the following investigators, who will make the final selection: Dr. Frederick G. Germuth, Jr., Associate Professor of Pathology, Johns Hopkins University Medical School, Baltimore 5, Md.; Dr. Colin M. MacLeod, Professor of Research Medicine, University of Pennsylvania, 820 Maloney Clinic, 36th and Spruce Streets, Philadelphia 4, Pa.; or Dr. Herman N. Eisen, Professor of Medicine (Dermatology) Washington University School of Medicine, Saint Louis, Mo.

Waterman Renominated NSF Head

Alan T. Waterman has been renominated by President Eisenhower for a second 6-year term as director of the National Science Foundation. Waterman's name was sent to the Senate for confirmation on 1 Apr. He was sworn in as first director of NSF on 6 Apr. 1951.

Reactor Exports

The U.S. Atomic Energy Commission has filed notice of proposed issuance of licenses for the export of two research reactors to the Danish Atomic Energy Commission. Applications for the licenses have been filed by the Foster Wheeler Corporation of New York and Loretz

and Company of Los Angeles, Calif. Both reactors will go to the nuclear research center being developed by the Danish Government near Roskilde, about 20 miles west of Copenhagen.

Foster Wheeler plans to ship a 5000-kilowatt tank-type reactor. Loretz and Company will send a solution-type reactor, built by Atomics International of Canoga Park, Calif., that operates at a power level of 500 watts.

The AEC has also announced that it has issued a license to AMF Atomics, Inc., of New York for the export of a research reactor to West Germany.

Detectolab, Inc.

Detectolab, Inc., formerly a Chicago, Ill., affiliate of the Borg-Warner Corporation, has been consolidated into BJ Electronics, Borg-Warner's electronics division in Santa Ana, Calif. Detectolab manufactures four major types of nuclear instruments. Ray Weiland, one of the original founders of Detectolab, Inc., will serve as Detectolab product manager at BJ Electronics.

French Scientific Bibliographies

The French Cultural Services will publish bibliographies of French scientific works. The first, which covers the years 1951-53, is now available and will be distributed free of charge.

Proposed Legislation

Of the many bills introduced in Congress, some have a special relevance to science and education. A list of such bills introduced recently follows:

S 724. Provide for scientific study and research program for purpose of developing increased and additional industrial uses of agricultural products to reduce surpluses of such products and to increase income of farmers. Capehart (R Ind.) *et al.* Senate Agriculture and Forestry.

HR 3374. Encourage expansion of teaching and research in education of mentally retarded children through grants to institutions of higher learning and to state educational agencies. Cunningham (R Iowa) House Education and Labor.

HR 3485. Amend Public Health Service Act to provide for research and investigation *re* cause, prevention, and treatment of multiple sclerosis and related neurological diseases. Hoeven (R Iowa). House Interstate and Foreign Commerce.

HR 3516. Authorize Walter Reed Army Institute of Research to award

master of science, master of public health, and doctor of science degrees in medicine, dentistry, veterinary medicine, and the biological sciences involved in health services. Bates (R Mass.) House Armed Services.

HR 3238. Provide for extension of terms of patents where use, exploitation, or promotion thereof was prevented, impaired, or delayed by causes due to war, national emergency. Keeney (R Ill.) House Judiciary.

HR 3377. Promote national defense by authorizing construction of aeronautical research facilities and the acquisition of land by National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research. Durham (D N.C.) House Armed Services.

HR 3419. Authorize contributions to colleges and universities to provide buildings for instruction in military science. Van Zandt (R Pa.) House Armed Services.

S Res 55. Examine administration of Patent Office and statutes *re* patents, copyrights, and trademarks. Eastland (D Miss.) Senate Judiciary.

HR 3388. Amend Communications Act of 1934, to direct Federal Communications Commission to provide for licensing of television reflector facilities and VHF translator facilities. Horan (R Wash.) House Interstate and Foreign Commerce.

HR 3424. Create a Department of Transportation and Communications and prescribe its functions. Younger (R Calif.) House Government Operations.

HR 3394. Relating to certain inspections and investigations in metallic and nonmetallic mines and quarries (excluding coal and lignite mines) for purpose of obtaining information *re* health and safety conditions, accidents and occupational diseases therein. Kelley (D Pa.) House Education and Labor.

HR 3237. Authorize state of Illinois and Metropolitan Sanitary District of Greater Chicago, under direction of Secretary of Army, to test, on a 3-year basis, the effect of increasing the diversion of water from Lake Michigan into the Illinois Waterway. Keeney (R Ill.) House Public Works.

Scientists in the News

ALAN T. WATERMAN, director of the National Science Foundation, has received the first annual Captain Robert Dexter Conrad award of the Office of Naval Research. The award has been established to recognize outstanding technical and scientific achievements in research and development for the Navy. It is named for Captain Conrad, who, as first head of the Planning Division of

ONR, was the primary architect of the Navy's basic research program.

The citation, signed by the Secretary of the Navy, reads as follows:

"For your outstanding contribution to the organization and long-range scientific objectives of scientific research administration in the Navy. For your vision and leadership in the successful establishment of new concepts and programs in Naval Science. For your personal and exemplary dedication to the building of a solid foundation for the role of the Office of Naval Research in the modern Navy, thereby creating a permanent benefit to the National Defense."

Waterman joined ONR in 1946 at its inception. Under his guidance and leadership, ONR became a laboratory for developing effective relationships and procedures between Government and science. His reputation for integrity and his forthright views on freedom of scientific direction, coupled with his standing in the scientific community, silenced scientists' fears that Government support would mean a loss of scientific freedom. This pioneering work in Government-science relationships has resulted in an expansion of scientific support by other Government agencies.

Waterman also realized the great need for scientific manpower, and the ONR contract research program emphasized advanced technical training and assistance to graduate students. The transition of the scientific and technologic potential of ONR from wartime development to peacetime research was smoothly accomplished under Waterman's direction.

MYRON G. DEFRIES, formerly chief of the test section at the Army Prosthetics Research Laboratory in the Walter Reed Army Medical Center, Forest Glen, Md., has joined the chemistry division of the Atlantic Research Corporation, Alexandria, Va. He will be concerned with polymer chemistry research in connection with the company's solid propellant rocket fuel projects.

JAMES B. CONANT, chemist, former president of Harvard University, and recently ambassador to the Republic of Germany, will undertake a study of some of the problems of the comprehensive high school in the United States. The Carnegie Corporation of New York will support his research.

Conant, who will be assisted by several coworkers, is now making plans for the work, which he expects to start next fall. He will be particularly interested in the education of the more talented youth of the community. He expects to turn for advice to the Educational Testing Service, the National Education Association, and the American Council on Education.

MARION A. BLANKENHORN, professor emeritus of the College of Medicine, University of Cincinnati, has been appointed director of education in the department of internal medicine of the Jewish Hospital, Cincinnati, Ohio. Blankenhorn, who has done work in pathology for the Rockefeller Institute, is a regent and former governor of the American College of Surgeons.

WLADIMIR PHILIPPOFF, principal scientist at the Franklin Institute Laboratories for Research, has been appointed chief of the rheology section that was recently established in the chemistry and physics division of the laboratories. A member of the staff since 1952, Philippoff has been engaged in research on rheological and structural properties of colloids and polymers and in the development of new methods for measuring the mechanical properties of such materials.

Philippoff was a member of the staff of the Kaiser Wilhelm Institute of Chemistry for 15 years before he came to the United States in 1948. His publications include a book entitled *Viskosität Der Kolloide*, which has been used widely as a definite treatment of viscosity.

Z. I. KERTESZ, professor of chemistry in the department of food science and technology at the New York State Agricultural Experiment Station, Cornell University, Geneva, has been granted a sabbatical leave to allow him to serve as food technologist on a military nutrition survey in Turkey. The 3-month survey will start in April and will be under the joint auspices of the Turkish Government and the U.S. Interdepartmental Committee on Nutrition for National Defense.

WILLIAM F. HEWITT, professor of physiology and acting chairman of the division of the basic sciences at Des Moines Still College of Osteopathy and Surgery, has accepted the position of director of pharmaceutical information in the research laboratories of Mead Johnson and Company in Evansville, Ind., effective 1 Apr.

Outstanding research achievements earned Borden awards of a gold medal and \$1000 for each of nine American scientists during 1956. The winners, to whom the awards have already been presented, are named in an annual directory just released by the Borden Company Foundation. The 1956 recipients and the administering groups are as follows:

SAM R. HOOVER, assistant executive director, President's Commission on Increased Industrial Use of Agricultural Products, for studies relating the prop-

erties of casein to its chemical constitution (administered by the American Chemical Society).

FRANK M. STRONG of the University of Wisconsin, for studies of numerous naturally occurring, physiologically active organic substances (administered by the American Institute of Nutrition).

A. ASHLEY WEECH of the University of Cincinnati College of Medicine, for contributions in the fields of pediatric investigation, with particular reference to rickets, nutritional edema, and physiological hyperbilirubinemia (administered by the American Academy of Pediatrics).

HARRY S. N. GREENE of the Yale University School of Medicine, for significant studies on the transplantation of tumors (administered by the Association of American Medical Colleges).

HERBERT L. GILMAN of the New York State Veterinary College at Cornell University, for outstanding research contributing to dairy cattle disease control (administered by the American Veterinary Medical Association).

ERNEST O. HERREID of the University of Illinois, for research on a wide variety of problems relating to the processing of dairy products (administered by the American Dairy Science Association).

PAUL D. STURKIE of Rutgers University, for his studies on the effects of potassium, thiamin, vitamin E, and drugs on heart function in the fowl, and the role of hormones and drugs on blood pressure, volume, and composition (administered by the Poultry Science Association).

HELEN L. GILLUM of the University of California, for work in organizing and carrying out the Western Regional nutrition study entitled "Nutritional Status of the Aging" (administered by the American Home Economics Association).

HARRY A. HERMAN, executive secretary of the National Association of Artificial Breeders, for notable work in the nutrition and breeding of dairy animals (administered by the American Dairy Science Association).

JOHN H. YOE, chairman of the chemistry department of the University of Virginia and director of the university's Pratt Trace Analysis Laboratory, received the \$1000 Fisher award in analytical chemistry on 8 Apr. during the 131st national meeting of the American Chemical Society. He was further honored by the society's division of analytical chemistry, which arranged a special program in recognition of his achievements as a pioneer in the fields of colorimetric analysis and the use of organic analytic reagents.

Brig. Gen. KENNETH E. FIELDS, U.S.A. (retired), general manager of the Atomic Energy Commission, has received the Distinguished Service Medal. The presentation was made by Lewis L. Strauss, chairman of the AEC, on behalf of Gen. Maxwell D. Taylor, chief of staff, U.S. Army.

Fields has been general manager since May 1955; before that date he was director of the commission's Division of Military Application. He was honored for outstanding service in that post. The citation stated that he had "rendered exceptional service in the planning, organization and direction of the atomic energy weapons program and in the coordination of this program with the requirements of the Department of Defense. His resourcefulness, sound judgment, extensive technical knowledge, and untiring efforts contributed greatly to our present state of readiness for nuclear warfare, thereby tremendously enhancing the security and common defense of the United States. . . ."

KURT ATERMAN, senior lecturer in the department of anatomy at the Medical School of Birmingham, Birmingham, England, has been appointed the first May Cave Willet research postdoctoral fellow in Lying-in Hospital of the University of Chicago. The appointment, supported through a grant of \$100,000 by Howard Willett, Sr., in honor of his wife, is one of the first made to initiate Lying-in Hospital's new research program in the physiology of reproduction.

Aterman is undertaking a study of histological and chemical changes in the cells of the endometrium, the lining of the uterus, using electron microscopy. It is suspected that defects in the mechanism of the endometrium are sometimes responsible for miscarriage.

HARRY EAGLE will deliver the 54th annual Christian A. Herter lecture of the New York University College of Medicine at 4 p.m., on 10 Apr., in the amphitheater of the Bellevue Psychiatric Hospital, New York. Eagle, who is chief of the section on experimental therapeutics of the National Institute of Allergy and Infectious Diseases, National Institutes of Health, will speak on "The metabolism of amino acids in tissue culture."

WILHELM KLEMM, chemist, of Munster University, Germany, will be guest speaker at the first dinner of the American Chemical Society's new division of inorganic chemistry that will take place on 10 Apr. at the Biscayne Plaza Hotel, Miami, Fla., during the society's annual meeting. He will speak on complex materials containing oxygen and fluorine. Klemm also will take part in an

all-day symposium on "Unfamiliar oxidation states of the elements," which will consider new methods of deriving important industrial raw materials.

Another visitor from abroad who will attend the ACS meeting is RONALD S. NYHOLM, professor of inorganic chemistry at Imperial College, London, England. He will participate in a symposium on "The present status of inorganic chemistry."

WILLARD C. RAPPLEYE, dean of the Faculty of Medicine at Columbia University since 1931, has received the Federation of State Medical Board's award of merit for "early and continued leadership in promoting the welfare of the medical profession."

Recent Deaths

WILLIAM S. BARTON, Pasadena, Calif.; 59; science editor of the *Los Angeles Times*; 12 Mar.

CYRUS W. CULVER, Washington, D.C.; 71; former clinical professor of obstetrics at George Washington University School of Medicine; 17 Mar.

JOHN W. HALL, Jackson Heights, N.Y.; 50; professor of pathology at the New York University College of Medicine; 20 Mar.

SEALE HARRIS, Birmingham, Ala.; 87; discoverer of hyper-insulinism; former owner and editor of the *American Medical Journal*; 16 Mar.

PETER M. HELDT, Nyack, N.Y.; 82; retired engineering editor of *Automotive Industries*; 12 Mar.

JOHANNES K. PETSCHOW, Glen Ridge, N.J.; 59; chief chemist for the Royce Chemical Company; 18 Mar.

JOHN B. ROXBY, Swarthmore, Pa.; 85; professor emeritus of anatomy at the Temple University Medical School; 18 Mar.

EARL R. SERLES, River Forest, Ill.; 66; dean of the College of Pharmacy of the University of Illinois; 13 Mar.

HENRY E. SIGERIST, Pura, Switzerland; 65; retired professor and director of the Institute of Medical History at Johns Hopkins University; vice president of AAAS Section L in 1943; 17 Mar.

PERCY H. THOMAS, Montclair, N.J.; 84; retired electrical engineer; 18 Mar.

BORIS YUREV, Moscow, Russia; 68; aeronautical engineer who twice won the Stalin prize for his work in aeronautics, which included helicopter construction; announced 17 Mar.

GEORGE ZILINSKAS, Waterbury, Conn.; former professor of anatomy at the University of Vytautas the Great and vice dean of the medical school in Kaunas, Lithuania; 16 Mar.

Reports

Effect of Somatotropin on Cells in Tissue Culture

The growth-promoting effect of somatotropin (pituitary growth hormone) in hypophysectomized and intact animals has been known for many years. However, there has been no evidence indicating its site of action—that is, whether somatotropin acts directly on cells or whether its effects are mediated by a "target organ" (1). In earlier studies, Baker and Carrel (2) observed that cells derived from a rat sarcoma grew readily in a culture medium containing large amounts of an extract of pepsin-digested pituitary glands. Inasmuch as pituitary growth hormone is destroyed by peptic digestion (3), the results of these investigators must be attributed to substances other than somatotropin. Recently, Fell (4) has reported that growth hormone has no discernible effect on limb buds of chick embryos in tissue culture. The purpose of this study (5) was to determine the direct effect of somatotropin on cells in tissue culture. These experiments indicate that somatotropin acts directly on cells, as manifested by an increased rate of multiplication of cells and an increased rate of protein synthesis.

Pituitary growth hormone, prepared by a method previously reported (6), was used. The growth hormone solution was ultrafiltered to insure sterilization and then lyophilized. The same preparation of somatotropin, the activity of which had been determined in hypophysectomized rats, was used in all experiments. The final concentrations of growth hormone in the culture medium were 25, 50, 100 and 200 µg/ml in the various experiments.

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

Stock cultures of cells (7) were grown in media consisting of 40 percent ox serum, 50 percent medium 199 (8), and 10 percent chick embryo extract. At the beginning of each experiment, the culture medium was removed from stock cultures, and a solution of 0.25 percent trypsin (9) was added to detach the cells from the surface of the glass and to separate the individual cells from one another. At room temperature, this occurred approximately 10 to 15 minutes after the trypsin solution had been added. The cell suspension was centrifuged at 1000 rev/min for 10 minutes. The supernatant was removed; the cells were resuspended in 20 ml of medium 199 and mixed thoroughly by pipetting. A direct count was made using standard WBC pipettes and hemocytometers. A quantity of the suspension sufficient to give a final concentration of 100,000 cells/ml was then added to a medium consisting of 90 percent medium 199 and 10 percent serum.

The basic culture medium used for all experiments consisted of 90 percent medium 199 and 10 percent ox serum. No embryo extract was added to any cultures. The growth hormone was mixed in medium 199 in a concentration 10 times that finally desired. In each instance, 0.5 ml was pipetted into the bottom of a T-30 flask, following which 4.5 ml of cell suspension was rapidly added to each flask; the suspension was stirred during this procedure. The flasks were then stoppered and incubated at 36°C. After 48 hours, 0.5 ml of the hormone solution was again added.

After a total of 96 hours' incubation, the medium was poured off and 5 ml of 0.1M citric acid was added. The cultures were incubated at 36°C for 2 to 3 hours. The number of cells was determined by the method reported by Sanford *et al.* (10). The figures given in Table 1 represent the average values obtained from three separate determinations on each flask; two to four flasks were used for each group.

The rate of growth of both the experimental and control cultures varied greatly from one experiment to another. However, the results obtained on the individual flasks of any given group were

in reasonably close agreement. There was consistently a greater number of cells in the media containing somatotropin than in the respective controls (Table 1). In some instances, the increase was slight and was within the limits of experimental error, whereas in other instances the increase in number of cells was great. A quantitative relationship could not be demonstrated between the concentration of somatotropin and the cellular response in these experiments.

In further studies, the growth response was measured by quantitative determination of the tyrosine content of the cells, as reported by Oyama and Eagle (11). The procedures used in these experiments were identical with those used in the previous experiments except for the difference in technique for measuring growth.

As in the experiments in which the cells were enumerated, the rate of growth of cells was consistently greater in the media with growth hormone than it was in the controls (Table 2). The increased rate of growth was slight in some experiments and great in others. A quantitative relationship between the growth response and the concentration of growth hormone could not be established. However, when concentrations of growth hormone ranging from 25 to 200 µg/ml were run simultaneously, the results were suggestive of such a relationship.

There have been numerous studies concerned with the morphologic and metabolic effects of somatotropin (12). As a result of these investigations, it has been established that somatotropin promotes an increased rate of growth of intact and hypophysectomized animals with participation in this process by most tissues. It has also been determined that somatotropin exerts a protein anabolic effect and influences carbohydrate and fat metabolism *in vivo*. However, there has been no evidence to suggest that

Table 1. Effect of somatotropin on growth of fibroblasts in tissue culture.

Somatotropin		No. of cells in controls (1000 cells/ml)
Concn. (µg/ml)	No. of cells (1000 cells/ml)	
50	338	327
50	289	258
100	185	148
100	437	375
100	609	496
100	441	410
200	523	430
200	433	418

Table 2. Effect of somatotropin on protein synthesis in tissue culture.

Somatotropin		Controls tyrosine ($\mu\text{g/ml}$)
Dose ($\mu\text{g/ml}$)	Tyrosine ($\mu\text{g/ml}$)	
50	13.6	13.2
100	11.4	9.6
200	15.0	13.6
200	13.2	11.9
200	9.2	6.5
200	14.8	11.2
25*	14.6	12.6
50*	15.7	12.6
100*	14.9	12.6
200*	17.0	12.6
25†	11.2	10.2
50†	11.0	10.2
100†	12.0	10.2
200†	13.9	10.2

* These experiments were run simultaneously.

† These experiments were run simultaneously.

somatotropin acts directly on individual cells. The present observations indicate that somatotropin exerts a significant growth-promoting effect at the cellular level that is manifested by an increase in number of cells and in the rate of protein synthesis.

HENRY D. MOON
LEONE ST. VINCENT

Department of Pathology and
Cancer Research Institute,
University of California
School of Medicine, San Francisco

References and Notes

1. We gratefully acknowledge the advice and assistance of C. Henry Kempe of the department of pediatrics, University of California School of Medicine, San Francisco, and of Hao Li of the Hormone Research Laboratory, University of California, Berkeley.
2. L. E. Baker and A. Carrel, *J. Exptl. Med.* 47, 371 (1928).
3. C. H. Li, H. M. Evans, M. E. Simpson, *J. Biol. Chem.* 159, 353 (1945).
4. H. B. Fell in *International Symposium, The Hypophyseal Growth Hormone, Nature and Actions*, R. W. Smith, O. H. Gaebler, C. N. H. Long, Eds. (McGraw-Hill, New York, 1955), pp. 138-153.
5. This investigation was aided by research grant C-2155 from the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service; American Cancer Society Institutional Grant 43; a grant from the E. C. Fleischner Memorial Fund and from the Edwards Fund by the Committee of Research, University of California, San Francisco.
6. C. H. Li, *J. Biol. Chem.* 211, 555 (1954).
7. The cells were a strain developed in our laboratory from 14-day-old embryos of Long-Evans rats. The strain is now in the 75th passage and has been subcultured once weekly. The morphologic characteristics indicate that these cells are fibroblasts.
8. J. F. Morgan, H. J. Morton, R. C. Parker, *Proc. Soc. Exptl. Biol. Med.* 72, 1 (1950).
9. Difco Laboratories.
10. K. K. Sanford et al., *J. Natl. Cancer Inst.* 11, 773 (1951).
11. V. I. Oyama and H. Eagle, *Proc. Soc. Exptl. Biol. Med.* 91, 305 (1956).
12. R. W. Smith, O. H. Gaebler, C. N. H. Long, Eds., *International Symposium, The Hypophyseal Growth Hormone, Nature and Actions* (McGraw-Hill, New York, 1955).

23 January 1957

Oxygen Consumption in Ovulating Fragments of Ovaries of *Rana pipiens*

It has been reported previously (1) that two known inhibitors of the cytochrome oxidase system inhibit *in vitro* ovulation of fragments of ovaries of *Rana pipiens*. Since the specificity of these inhibitors (KCN and sodium azide) is neither perfectly established nor invariable, the following experiments were undertaken to study further the dependency of ovulation on oxygen by (i) observing the effect of anaerobic incubation on ovulation in isolated ovarian fragments, (ii) comparing the oxygen consumption of ovulating and non-ovulating ovaries, and (iii) attempting to associate the inhibitory effect of cyanide on ovulation with concomitant inhibition of oxygen consumption.

Standard techniques of Warburg respirometry were used (2). A fragment of ovary containing 20 eggs was placed in each manometer flask. The total volume of fluid and tissue was kept at 4 ml throughout the respirometry. In all runs the system was allowed to equilibrate for $\frac{1}{2}$ hour before readings were begun. In view of the potential danger of damage to the follicles from continuous shaking over the necessarily long incubation period of 24 hours, the manometers were shaken (80 cycles per minute) only during the 20-minute period immediately preceding a reading. For experiments involving anaerobic incubation, manometer flasks were gassed with either carbon dioxide (in which case the KOH was omitted) or nitrogen and allowed to equilibrate for $\frac{1}{2}$ hour. Ovulation was stimulated by the addition of pituitary homogenate in a volume representing one-sixteenth of a triturated homoplastic anterior lobe.

Under anaerobic conditions, ovulation was not observed in 18 ovarian fragments taken from six frogs. In 36 comparable control fragments, taken from the same frogs but incubated aerobically, 27.3 percent of the available follicles extruded eggs.

In Fig. 1 the data from an experiment measuring the oxygen consumption of a number of ovulating and nonovulating ovarian fragments are compared. Respiration was minimal during the first 12 hours of incubation, for ovulation did not begin until 10 to 12 hours after the introduction of pituitary extract. In four experiments, utilizing 27 fragments from ovaries of four frogs, the average rate of oxygen consumption over the entire incubation was found to be 1.64 $\mu\text{l/hr}$ in nonovulating fragments and 2.46 $\mu\text{l/hr}$ in ovulating fragments. In two experiments, in which ovarian fragments that were exposed to pituitary extract failed to ovulate, the average oxygen

consumption was 1.44 $\mu\text{l/hr}$. Analysis of the distribution of differences of 24 pairs of oxygen-consumption values from four experiments indicates a statistical confidence level of $p < 0.01$.

Control studies were carried out on (i) oxygen consumption of pituitary extract in the absence of fragments of ovary, (ii) oxygen consumption of freshly ovulated eggs in the absence of ovarian tissue, (iii) the effect on respiration of inhibiting maturation of ovulated eggs by colchicine, and (iv) the contribution to over-all oxygen consumption made by contaminant bacteria. The increased oxygen consumption observed in ovulating ovaries could not be shown to be owing to any of these factors.

The addition of potassium cyanide ($10^{-4}M$) to flasks containing fragments of ovary completely inhibited oxygen consumption in all flasks and completely inhibited ovulation in the flasks that contained pituitary extract. Upon introduction of methylene blue from a second side arm, which brought the concentration in the medium bathing the fragments to $10^{-5}M$, the rate of oxygen consumption returned to approximately normal and the fragments subsequently ovulated. Although ovulation in fragments so treated was not completely normal, it did reach an average of 62.5 percent of that seen in control fragments exposed to methylene blue but not to potassium cyanide.

It appears that the follicular mechanisms which respond to pituitary stimulation producing the discharge of ova are aerobic and utilize molecular oxygen through the cytochrome oxidase system; this constitutes presumptive evidence of energy expenditure in ovulation. These data are consistent with the hypothesis

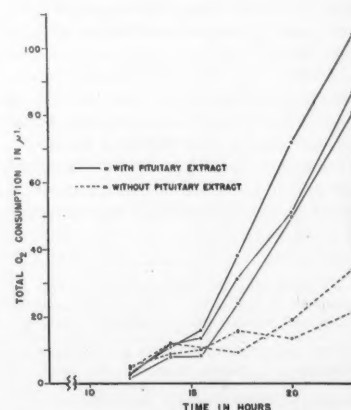


Fig. 1. Oxygen consumption in ovulating and nonovulating fragments. Each curve represents the course of oxygen consumption of a separate 20-egg fragment. Final ovulation of the fragments represented by the top three curves was 83 percent; by the bottom two curves, 0 percent.

that follicular smooth muscle cells (found only in Amphibia) are necessary for the extrusion of ova. However, the observations that $10^{-4}M$ KCN does not inhibit the normal contractions of intact, excised ovaries and that autonomic blocking agents, antihistamine, and smooth muscle depressants do not inhibit pituitary-induced ovulation suggest that the energy-consuming process is not muscular contraction. Ovulation seems more likely to be related to proteolysis of the stalk membrane or to more obscure processes supporting increased intrafollicular pressure.

PAUL A. RONDELL

Department of Physiology,
University of Michigan, Ann Arbor

PAUL A. WRIGHT

Department of Zoology,
University of Michigan

References

1. P. A. Rondell, *Anat. Record* 113, 546 (1952).
2. W. W. Umbreit et al., *Manometric Techniques and Tissue Metabolism* (Burgess, Minneapolis, Minn., 1951).

16 January 1957

Effect of Gibberellin on Germination of Lettuce Seed

The gibberellins are a group of plant regulators that were discovered nearly 20 years ago by Japanese scientists (1), and lately these compounds have attracted the attention of plant physiologists in many countries (2). The gibberellins which are known chemically are produced by strains of the fungus *Fusarium moniliforme* (Sheld.) Snyder and Hansen emend., the asexual stage of *Gibberella fujikuroi* (Saw.) W. R. Materials with identical physiological activity have been shown to occur also in flowering plants (3). The gibberellin effect that was observed first and has been studied in a wide variety of plants is promotion of stem elongation. More recently, however, it was found that the gibberellins also have profound morphogenetic effects; they induce bolting and flower formation in cold-requiring plants and in long-day plants under temperature and light conditions which usually do not permit flowering (4).

The finding that gibberellin can "replace" light (long days) in flower induction of long-day plants led to our study of the effects of gibberellin on the germination of light-requiring seeds, since the action spectra of the light control of flowering and of seed germination are similar (5). The purpose of this report is to summarize the findings that have been obtained to date (6, 7).

All our experiments have been performed with seeds of lettuce (*Lactuca*

Table 1. Effect of gibberellin on germination in the dark of lettuce seed possessing a natural ("primary") requirement of red light for germination (seed lot A).

Treatment	Germination (%)
Water	24
Water; 3 min of red light	70
Gibberellin (100 mg/lit)	70

sativa L., variety Grand Rapids). Several types of light effects are known for lettuce seed. Some lots yield low germination in the dark, and germination may be increased by a brief exposure to light; they may be said to have a "primary" light requirement. Other lots exhibit equal or nearly equal germination percentages in light and in darkness, but a "secondary" light requirement can be induced in at least two different ways: (i) if such seeds are imbibed and stored at a temperature of 35°C, their percentage germination in darkness is greatly reduced and can be restored to the original level or higher by a brief exposure to light (5); (ii) the presence of an osmotically active material in the medium reduces germination in the dark in direct proportion to the osmotic pressure of the solution, and this "dark-osmotic inhibition" is also released by a small quantity of light (7). It is likely that the basic mechanism of these light actions is the same, red light having the greatest effect in promoting germination of lettuce seed, and its effect being reversible by subsequent irradiation with far red light.

We have worked with two lots of seeds, one (seed lot A) possessing the primary type of light requirement and the other (seed lot B) acquiring the secondary type during pretreatment with high temperature or in the presence of an osmotically active material such as mannitol in solution (8). The gibberellin preparation used in these experiments consisted of a mixture of gibberellin A₁ (gibberellin A) and gibberellin A₃ (gibberellic acid) and will henceforth be called "gibberellin" (9).

Table 1 shows that the primary light requirement of seed lot A is bypassed by the addition of gibberellin. In the presence of 100 mg of gibberellin per liter, germination in darkness is as high as germination after a brief exposure to red light. An identical result has been reported by Lona (10) for light-requiring seeds of a wild species of lettuce, *Lactuca scariola* L.

Table 2 shows that, when gibberellin is present during pretreatment of seed lot B with high temperature, no secondary light requirement becomes apparent. As is shown in Table 3, gibberellin also promotes germination in darkness after a dependency on red light has been es-

tablished by pretreatment with high temperature; thus, it removes the secondary light requirement formed by the pretreatment. Table 4 shows that gibberellin also reduces or negates dark-osmotic inhibition when it is given simultaneously with the inhibitory solution or when it is supplied as a pretreatment.

Thus, in lettuce seed, gibberellin apparently can substitute for red light in all cases examined in which such light has a promotive effect on germination; it "replaces" the primary light requirement that is typical of certain seed lots, and it prevents or releases the secondary light requirement that can be created in other lots. Whether these effects are based on a common mechanism, and how they are related to the effect of red light, will have to be the subject of fur-

Table 2. Effect of gibberellin supply during treatment with high temperature on subsequent germination of lettuce seed in darkness at 21°C (seed lot B).

Treatment (5 days at 36°C)	Germination (%)
Water	20
Water; 10 min of red light following high-temperature period	94
Gibberellin (50 mg/lit)	92

Table 3. Effect of gibberellin supply after pretreatment with heat on germination of lettuce seed in darkness at 21°C (seed lot B). All seeds were given 5 days at 36°C on water and were completely dried following the pretreatment with heat.

Treatment	Germination (%)
Reimbibed on water	26
Reimbibed on water; then 10 min of red light	94
Reimbibed on gibberellin (50 mg/lit)	45
Reimbibed on gibberellin (100 mg/lit)	68

Table 4. Effect of gibberellin on dark-osmotic inhibition of lettuce seed (seed lot B); 0.15M mannitol was used.

Pretreatment (6 hr)	Solution	Gibberellin (mg/lit)	Germination (%)
None	Water	0	82
None	Mannitol	0	22
None	Mannitol	35	61
Water	Mannitol	0	23
Gibberellin (50 mg/lit)	Mannitol	0	87

ther studies. As is noted in a preceding paragraph, the action of red light is reversible by subsequent irradiation of seeds with far red light. The effect of gibberellin has not been reversed by a period of exposure to far red light that is sufficient to reverse fully the effect of red light. However, since gibberellin that has entered the seeds cannot be removed, the lack of reversal of the gibberellin effect by far red light cannot be considered definitive.

ALBERT KAHN
JAMES A. GOSS*

Department of Botany,
University of California, Los Angeles

DANIEL E. SMITH
Department of Floriculture and
Ornamental Horticulture, University
of California, Los Angeles

References and Notes

1. T. Yabuta and T. Hayashi, *J. Agr. Chem. Soc. Japan* 15, 257, 403 (1939).
2. B. Stowe and T. Yamaki, *Ann. Rev. Plant Physiol.*, in press.
3. C. A. West and B. O. Phinney, *Plant Physiol.* 31, Suppl., 20 (1956); M. Radley, *Nature* 178, 1070 (1956).
4. A. Lang, *Naturwissenschaften* 43, 284, 544 (1956).
5. H. A. Borthwick *et al.*, *Botan. Gaz.* 115, 205 (1954).
6. This work was supported in part by research grant RG-3939 from the National Institutes of Health, U.S. Public Health Service (principal investigators, A. Lang and S. G. Wildman). A description of the details of these experiments and the results of further work now in progress is in preparation.
7. Part of the results reported here were presented at the annual meeting of the American Society of Plant Physiologists, Storrs, Conn., Aug. 1956; abstract in *Plant Physiol.* 31, Suppl., 37 (1956).
8. Seed lot A was kindly supplied by Carlos O. Miller of the department of botany, University of Wisconsin, Madison; seed lot B was obtained commercially from Ferry Morse Seed Co.
9. [a]_D²⁰ + 62°. We wish to express our gratitude to Frank H. Stodola, U.S. Department of Agriculture, for supplying the preparation.
10. F. Lona, *L'Ateneo Parmense* 27, 641 (1956).

* Present address: Department of Botany, Kansas State College, Manhattan.

17 January 1957

Survey of Fungi and Actinomycetes for Compounds Possessing Gibberellinlike Activity

Culture filtrates of the fungus *Gibberella fujikuroi* contain the plant growth-promoting compounds gibberellins A and B (1) and gibberellic acid (2). Recently, it has been shown that extracts of higher plants contain gibberellinlike compounds capable of stimulating growth in plants (3). This report describes an attempt to demonstrate plant growth-promoting activity similar to that of the gibberellins in the culture filtrates of various fungi and actinomycetes. Approximately 1000 fungus and 500 actinomycete culture filtrates were tested for the presence of these compounds.

The methods used to obtain culture filtrates of the various microorganisms were described in an earlier paper (4). In brief, the fungi were cultured in 500-ml erlenmeyer flasks containing 100 ml of corn steep-cerelease medium (Staley's corn steep liquor, 40.0 g; cerelease, 40.0 g; CaCO₃, 5.5 g; NaNO₃, 3.0 g; K₂HPO₄, 0.5 g; MgSO₄, 0.25 g; and deionized water, 1000 ml). Following inoculation, the flasks were placed on a reciprocating shaker (99 to 100 cy/min with 3-inch strokes) at 28°C for 7 days. The mycelial growth in each flask was removed by filtering through Whatman No. 1 filter paper and discarded. One drop of Tween 80 was added to 100 ml (approximate) of culture filtrate, which was adjusted to pH 5.0. The culture filtrates were tested without dilution or concentration.

The methods used to obtain the actinomycete culture filtrates were similar to those described in the preceding paragraph. The shake-flask medium (pH 7.0) was made up as follows: bacto-peptone, 5.0 g; glucose, 10.0 g; molasses (Brer Rabbit Green Label), 20 ml; FeSO₄ · 7 H₂O, 0.01 g; and distilled water, 1000 ml. The cultures were incubated on a reciprocating shaker (114 cy/min with 2-inch strokes) for 5 days at 30°C. The culture filtrates were treated as described for fungi and frozen until they were needed.

Corn seedlings (the single cross WF9 × 38-11) were grown in soil in 6-inch pots (six plants per pot). When the seedlings were 6 to 8 cm in height, they were treated by filling the whorls with the culture filtrates on each of two alternate days. The treated plants were allowed to grow for 10 to 12 days, when their heights were measured. Water and the uninoculated culture medium (without carbon source) served as the controls. Twelve to 18 plants were used for each treatment.

By use of the methods described, it was readily demonstrated that the heights of plants that were treated with the culture filtrate of *Gibberella fujikuroi* were 50 to 75 percent greater than those of the controls. Although some 1500 culture filtrates from other sources were used in treating corn plants, in no case was growth stimulation observed. The majority of the culture filtrates tested were obtained from unidentified fungi and actinomycetes that were obtained from soil by routine plating-out procedures. However, 258 filtrates were obtained from organisms which were identified as to genus or species. Table 1 summarizes briefly the major groups of organisms that were tested and the number of genera and species included in each group (5).

The number of organisms tested in these studies is admittedly only a small

Table 1. Summary of identified fungi and actinomycetes tested for growth stimulation in corn.

Major groups included in experiments	No. of genera tested	No. of species tested
Schizomycetes		
Actinomycetales	2	7
Phycmycetes		
Pteronospores	2	7
Mucorales	16	35
Entomophthorales	1	1
Ascomycetes		
Endomycetales	5	8
Eurotiales	9	31
Sphaeriales	7	11
Hypocreales	2	2
Pezizales	3	3
Basidiomycetes		
Ustilaginales	1	1
Agaricales	3	3
Fungi Imperfecti		
Sphaeropsidales	3	3
Melanconiales	1	1
Moniliales	42	141
Mycelia-Sterilia	3	3

fraction of the total number of identified microorganisms. Furthermore, they were grown on only one medium and tested at only one concentration. In spite of these limitations, it appears that the production of the gibberellins by fungi and actinomycetes is not widespread (6).

ROY W. CURTIS

Department of Botany and
Plant Pathology,
Purdue University, Lafayette, Indiana

References and Notes

1. T. Yabuta and T. Hayashi, *J. Agr. Chem. Soc. Japan* 15, 257 (1939).
2. P. J. Curtis and B. E. Cross, *Chemistry and Industry* 1954, 1066 (1954); F. H. Stodola *et al.*, *Arch. Biochem. and Biophys.* 54, 240 (1955).
3. M. Radley, *Nature* 178, 1070 (1956); C. A. West and B. O. Phinney, *Plant Physiol.* 31, XX (1956).
4. R. W. Curtis, *Plant Physiol.*, in press.
5. Most of the identified cultures used in these studies were generously supplied by K. B. Raper and M. P. Backus (University of Wisconsin) and A. J. Ullstrup and J. Tuite (Purdue University). The actinomycete culture filtrates were furnished by the Eli Lilly Company, Indianapolis, Ind.
6. Journal paper No. 1062 of the Purdue Agricultural Experiment Station.

22 January 1957

Occurrence of Iron, Copper, Calcium, and Magnesium in Tobacco Mosaic Virus

Cooper and Loring reported the finding of small amounts of acid-soluble materials when ultracentrifugally purified tobacco mosaic virus was treated with cold trichloroacetic acid (1). Examination of a concentrate of this fraction by paper chromatography (70 percent *tert*-butyl alcohol, 0.8N HCl) showed that

a component was present which behaved like ferrous iron when the chromatogram was sprayed with the perchloric acid-molybdate reagent of Hanes-Isherwood (2). A study of the emission spectra of a sample of virus ash confirmed the occurrence of iron in the virus and provided evidence for copper, calcium, and magnesium as well.

In order to establish the amounts of the four metals present, quantitative chemical analyses (3) were performed on 0.1N HCl solutions of virus ash prepared from different virus samples that had been purified by three or four ultracentrifugal purification cycles (4). The results confirmed the data obtained by paper chromatography and by emission spectroscopy and provided average values (Table 1) of about 30 µg of iron, 20 µg of copper, 300 µg of calcium, and 600 µg of magnesium per gram of virus.

In order to obtain evidence regarding the type of binding involved between the metallic components and the virus, various types of dialysis and ultracentrifugation experiments which would be expected to remove adsorbed metallic impurities were carried out. The types of treatment included equilibration in and ultracentrifugation from 0.5-percent ethylenediaminetetraacetic acid (EDTA) solution (5) at pH 7 and pH 8 and dialysis (6) at 4°C against water and 0.5 percent EDTA at pH 7. In each case, the virus was recovered by ultracentrifugation, lyophilized, and ashed, and aliquots of the 0.1N HCl solution of ash were analyzed.

The results of these experiments are summarized in Table 1. They show decreases particularly in calcium and magnesium content after treatment with or dialysis against EDTA, but iron and copper were relatively unaffected. After dialysis against EDTA for 7 days, further decreases appeared to occur, but significant amounts of all four components were still present. Similarly, dialysis against distilled water for 24 hours showed a significant decrease in magnesium content, but the concentrations of the other three metallic components were largely unchanged.

The recovered virus in each of the experiments shown was tested for activity by the local-lesion method (7) against the same concentration of untreated, purified virus. The half-leaf method was used on five or six of the largest leaves of the Holmes necrotic-type *Nicotiana tabacum* plants (8) 8 to 14 inches tall. From the activity measurements shown in Table 2, it may be seen that highly active virus comparable to the original was recovered in all cases with the possible exception of the sample that was dialyzed against EDTA at pH 7 for 7 days. In this instance, the dialyzed virus was probably slightly less

Table 1. Metal content of purified tobacco mosaic virus before and after various treatments. The values are averages for at least two analyses, usually on two samples of ash.

Treatment	Metal content (µg/g of virus)			
	Fe	Cu	Ca	Mg
Virus after three purification cycles*	29	23	330	670
Equilibration with 0.5 percent EDTA at pH 7	27	13	84	48
Equilibration with 0.5 percent EDTA at pH 8	54	21	95	50
Dialysis against 5 percent EDTA at pH 7 for 24 hours	47	16	200	100
Dialysis against water for 24 hours	42	22	350	200
Dialysis against 0.5 percent EDTA at pH 7 for 7 days	22	4	42	22

* Average values for two different samples of virus.

active than the untreated preparation that was stored in the refrigerator over the same period of time.

It was of interest to determine whether the metallic components found in the virus were associated with the virus protein, with its ribonucleic acid, or with both. Analyses of a sample of the nucleic acid prepared by the method of Johnson and Harkins (9) from purified virus showed that all four metallic components were present and that the iron and magnesium occurred in about 20 times the concentration present in the virus itself. The amounts found in micrograms per gram of nucleic acid were as follows: iron, 640; copper, 31; calcium, 210; magnesium, 1900. Dialysis of a 2.5-percent solution of the virus nucleic acid at 4°C for 24 hours against 0.1M phosphate at pH 7 eliminated the calcium completely and decreased the magnesium concentration to about one-tenth of the original value but had only a slight effect on iron and copper. Dialysis against a mixture of 0.1M phosphate and 0.5-percent EDTA under the condition mentioned reduced the iron content to approximately one-fourth of the original value, eliminated copper and calcium completely, and decreased the magnesium content only slightly beyond that found after phosphate dialysis.

In agreement with earlier reports of

Zittle (10) and Jungner (11), copper and magnesium were also found in two samples of commercial yeast sodium ribonucleate. No calcium was found, but iron was present in amounts comparable to that mentioned for the virus nucleic acid. The respective average values in micrograms per gram for the two samples were as follows: iron, 590 and 380; copper, 340 and 500; and magnesium, 900 and 800.

Although various lines of evidence have shown that the tobacco mosaic virus consists essentially of protein and nucleic acid (12, p. 18), the virus has not been examined previously for the metallic components mentioned as far as we are aware. The data presented here show that small amounts of relatively firmly bound iron, copper, calcium, and magnesium also occur in this virus. These results extend the earlier findings of trace metals in certain animal viruses (13) to a plant virus of a high degree of homogeneity and of relatively simple biochemical complexity. Strong confirmation has thus been provided that iron, copper, magnesium, and probably calcium are integral viral components. In the present experiments it has not been possible to determine precisely the lower metal concentration compatible with full virus activity. An approximation of this, however, appears to be the concentra-

Table 2. Infectivity of tobacco mosaic virus after various treatments.

Treatment	Virus concn.* (g/ml)	No. of half-leaves	Avg. No. of lesions per half-leaf†	
			Treated	Control
Equilibration with EDTA at pH 8				
First treatment	10 ⁻⁴	10	24	24
Second treatment	10 ⁻⁵	9	8	10
Dialysis against 0.5 percent EDTA at pH 7 for 24 hours at 4°C	10 ⁻⁶	11	10	9
Dialysis against 0.5 percent EDTA at pH 7 for 7 days at 4°C				
First test	10 ⁻⁵	15	12	15
Second test	5 × 10 ⁻⁵	38	17	24
Dialysis against water for 24 hours at 4°C	10 ⁻⁵	10	93	50

* Dilutions prepared in 0.1M potassium phosphate buffer at pH 7.

† Differences, with possible exceptions of the samples dialyzed against EDTA for 7 days and against water, are not of statistical significance.

tions found in the virus dialyzed for 7 days against EDTA. Assuming a molecular weight for the virus of 50×10^6 , calculation of the number of atoms of iron, copper, calcium, and magnesium per virus particle gave values of 20, 3, 52, and 45, respectively.

The fact that iron and magnesium were concentrated approximately 20-fold in the virus ribonucleic acid compared with the occurrence of about 5 percent nucleic acid in the virus indicates that these metals are located in the nucleic acid rather than in the protein. That their occurrence in the virus nucleic acid in the concentrations found may be of more general significance in relation to nucleic acid chemistry is indicated by the comparable amounts found in yeast ribonucleic acid. The relatively strong binding of the virus ribonucleic acid for iron and magnesium as shown by the dialysis experiments against EDTA (5) indicates the existence of metal chelates or relatively stable metal complexes in ribonucleic acid structure. While the function of the individual metals in the virus or in its nucleic acid is not clear at present, some of them may be involved in the binding of smaller nucleic acid subunits into the larger asymmetric particles characteristic of "native" and infectious nucleic acid (14). Since the tobacco mosaic virus undergoes a disintegration into relatively small units soon after inoculation (15), it appears that the larger nucleic acid may undergo a subdivision into smaller genetic subunits during the infection process in a manner similar to that shown for bacteriophage by Doermann (16) and by Visconti and Delbrück (17). A further logical hypothesis is that the genetic subunits, the "vegetative phase" of Visconti and Delbrück, are joined into the larger asymmetric particles, the "genetic recombinants" characteristic of "native" and infectious ribonucleic acid by metal chelate bonds. Although no analyses for the metallic components considered in this paper have yet been made on "native" deoxyribonucleic acid, it is known that magnesium is present (11). The occurrence of smaller deoxyribonucleic acid units joined by metal chelate bonds into the highly asymmetric particles characteristic of "native" deoxyribonucleic acid would appear to provide a rational explanation for many of the physical (18) and biological (19) properties of this nucleic acid also (20).

HUBERT S. LORING
RICHARD S. WARITZ*

Department of Chemistry, and
School of Medicine, Stanford University,
Stanford, California

References and Notes

1. W. D. Cooper and H. S. Loring, *J. Biol. Chem.* 211, 505 (1956).
2. C. H. Hanes and F. A. Isherwood, *Nature* 164, 1107 (1949).

3. The procedure used for iron was essentially the *o*-phenanthroline method of S. L. Bandemer and P. J. Schaible [*Ind. Eng. Chem. Anal. Ed.* 16, 317 (1944)] reduced to a 2-ml scale. The colored solution was allowed to stand at 40°C for 30 minutes before the optical density was measured [R. Hamm, *Biochem. Z.* 327, 149 (1955)]. Copper was determined directly with dithione as given by E. B. Sandell [*Colorimetric Determination of Traces of Metals* (Interscience, New York, ed. 2, 1950), p. 303]. The murexide method for calcium [T. T. Gorsuch and A. M. Posner, *Nature* 176, 268 (1955)] was used in the presence of cyanide to avoid interference by copper. Magnesium was found by subtraction of the independently determined value for calcium from the combined calcium and magnesium concentration determined in the presence of cyanide by the EDTA titrimetric procedure of P. B. Sweetser and C. E. Bricker [*Anal. Chem.* 26, 195 (1954)] reduced to a 1-ml scale. Details of the modifications used are given by R. S. Waritz [dissertation submitted to Stanford University for the Ph.D. degree in chemistry (1956)].
4. C. A. Knight and W. M. Stanley, *J. Biol. Chem.* 141, 29 (1941).
5. Stability constants, $\log K$, for Fe^{II} , Cu^{II} , Ca^{II} , and Mg^{II} of 14.2, 18.3, 10.6 and 8.7, respectively [G. Schwarzenbach and H. Ackerman, *Helv. Chim. Acta* 31, 1798 (1947); G. Schwarzenbach and E. Freitag, *ibid.* 34, 1503 (1951)].
6. M. Kunitz and H. S. Simms, *J. Gen. Physiol.* 11, 641 (1928).
7. F. O. Holmes, *Botan. Gaz.* 87, 39 (1929); G. Samuel and J. G. Bald, *Ann. Appl. Biol.* 20, 70 (1933).
8. F. O. Holmes, *Phytopathology* 28, 553 (1938).
9. T. B. Johnson and H. Harkins, *J. Am. Chem. Soc.* 51, 1779 (1929).
10. C. A. Zittle, *J. Biol. Chem.* 163, 111 (1946).
11. G. Jungner, *Science* 113, 378 (1951).
12. N. W. Pirie, *Advances in Enzymol.* 5, 1 (1945). It is stated in this publication (p. 5) that traces of 12 metals besides calcium and sodium occur in dialyzed preparations of the bushy stunt virus, but no quantitative data are presented.
13. Copper was found as a component of vaccinia by C. L. Hoagland et al. [*J. Exptl. Med.* 74, 69 (1941)], and iron and magnesium as components of the silkworm virus by C. F. Holoway and G. H. Bergold [*Science* 117, 251 (1953); 122, 1266 (1955)]. Ferrous iron has been shown to occur in sufficient amounts in purified mouse encephalomyelitis virus to inhibit glycolysis [E. Racker and I. Krimsky, *J. Exptl. Med.* 85, 715 (1945)].
14. H. Fraenkel-Conrat, *J. Am. Chem. Soc.* 78, 882 (1956); A. Gierer and G. Schramm, *Nature* 177, 702 (1956).
15. W. M. Stanley, *J. Biol. Chem.* 121, 205 (1937).
16. A. H. Doermann, *J. Gen. Physiol.* 35, 645 (1952).
17. N. Visconti and M. Delbrück, *Genetics* 38, 5 (1953).
18. D. O. Jordan, in *The Nucleic Acids*, E. Chargaff and J. N. Davidson, Eds. (Interscience, New York, 1950), vol. 1, p. 447.
19. A. D. Hershey and M. Chase, *J. Gen. Physiol.* 36, 39 (1952); A. H. Doermann, M. Chase, F. W. Stahl, *J. Cellular Comp. Physiol.* 45, Suppl. 2, 51 (1955).
20. This investigation was supported in part by research grants from the American Cancer Society (grant No. BCH-40) and from the National Heart Institute, National Institutes of Health, U.S. Public Health Service (grant No. H-3888). We should like to express our thanks also to Saad Al-Rawi for assistance with some of the analyses; to F. L. Humphrey of the School of Mineral Sciences, Stanford University, for the measurement of the emission spectra; to C. A. Knight of the Virus Laboratory, University of California, for several samples of virus; and to C. Stacy French of the Carnegie Institution of Washington, Stanford, Calif., for the use of greenhouse facilities.

* Present address: Grasselli Chemicals Dept., Experimental Station, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

26 December 1956

Enzymatic Conversion of D-Glucose to D-Fructose

Xylose isomerase, which catalyzes the interconversion of D-xylose and D-xylulose, has been demonstrated in extracts of xylose-grown cells of *Pseudomonas hydrophila* (1), *Lactobacillus pentosus* (2), and *Pasteurella pestis* (3). Although it has been reported that other aldose-ketose isomerases (4, 5) isomerize series of structurally related aldoses, xylose isomerase has been described as unable to act on aldoses other than D-xylose. However, experiments in these laboratories have shown that sonic extracts and washed, lyophilized cells of xylose-grown *Pseudomonas hydrophila* (N.R.C. 491 and 492) (1) do in fact convert D-glucose to D-fructose. Similarly, 6-deoxy-D-glucose was converted to a sugar that readily reacted in the cysteine-carbazole test (6) and exhibited an R_f in paper chromatography substantially greater than that of 6-deoxy-D-glucose. It seems reasonable to assume that the sugar formed is 6-deoxy-D-fructose (5).

The ability of the enzyme preparations to isomerize D-xylose or D-glucose is a concomitant of growth in the presence of D-xylose as the major carbon source. Growth on D-glucose, D-fructose, or maltose gives rise to cells which are essentially devoid of isomerase activity for either D-xylose or D-glucose.

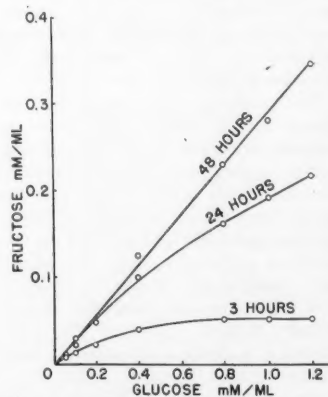


Fig. 1. Formation of D-fructose as a function of incubation time and initial D-glucose concentration. The final concentrations of the components of the incubation mixtures were as follows: arsenate buffer (pH 8.0), 0.05M; MgCl_2 , 0.01M; washed lyophilized cells of *Pseudomonas hydrophila* (N.R.C. 492), 10 mg/ml; and D-glucose as indicated. Final volume was 2.0 ml, and the incubation temperature was 40°C. The reaction was stopped by withdrawing 0.25-ml aliquots into 4.75 ml of 0.5M HClO_4 . After centrifugation and suitable dilution, fructose was estimated by a modification (9) of the cysteine-carbazole test. All values were corrected for the color contributed by D-glucose. The color contributed by the enzyme preparation was negligible.

The formation of D-fructose as a function of incubation time and initial D-glucose concentration is illustrated by Fig. 1. The data indicate that the affinity of the enzyme for D-glucose ($K_m = 0.5M$ at pH 8.0 and 40°C) is much lower than that reported for D-xylose ($K_m = 3 \times 10^{-3}M$ at pH 7.5 and 30°C, 3). The pH and temperature optima determined at 0.2M D-glucose concentration are about 8.5 and 42° to 43°C, respectively. The conversion can readily be demonstrated in the presence of a variety of buffer systems; however, the addition of arsenate or fluoride, which presumably block competing reactions, leads to an increased accumulation of D-fructose. Present evidence suggests a requirement for either magnesium or manganese ions, as is the case with xylose isomerization (1, 3).

The formation of D-fructose in the system was confirmed by isolation and characterization of the product. In a typical experiment, 90 g of D-glucose was dissolved in 500 ml (final volume) of 0.03M arsenate buffer (pH 8.0) containing 2.5 mmole of $MgCl_2$ and 5.0 g of lyophilized, xylose-grown *Pseudomonas hydrophila* cells. After incubation in a closed flask for 48 hours at 40°C, the mixture was analyzed as described in the legend for Fig. 1 and found to contain 29.2 g of D-fructose. The mixture was then deproteinized with 100 ml of 0.5M $HClO_4$ and centrifuged. The supernatant was deionized by passage over columns of Nalcite HCR and of Duolite A-3 resins; the effluent (pH 5.0) was concentrated in a vacuum to approximately 30 percent dry substance. D-Fructose was isolated from the resulting syrup as the insoluble calcium complex. Calcium was removed as the oxalate, and the D-fructose was crystallized from aqueous ethanol. The product, obtained in 18-percent yield based on initial D-glucose, had the following properties: $[\alpha]_D^{20} = -91.8^\circ$ (lit. = -92.0°); mp = 101 to 103°C (lit. = 102 to 104°C).

Although the role of xylose isomerase in the dissimilation of xylose has been recognized (7), present evidence warrants only speculation on the metabolic significance of the isomerization of other sugars by this enzyme. Further investigations are in progress on the levels of D-glucose isomerizing activity in other species of microorganisms, and on the substrate specificity of the enzyme (8).

RICHARD O. MARSHALL
EARL R. KOOI

George M. Moffett
Research Laboratories,
Corn Products Refining Company,
Argo, Illinois

References and Notes

1. R. M. Hochster and R. W. Watson, *Arch. Biochem. and Biophys.* 48, 120 (1954).
2. S. Mitsuhashi and J. O. Lampen, *J. Biol. Chem.* 204, 1011 (1953).
3. M. W. Sleis, *J. Am. Chem. Soc.* 77, 1663 (1955).

4. M. Green and S. S. Cohen, *J. Biol. Chem.* 219, 557 (1956).
5. M. J. Palleroni and M. Doudoroff, *ibid.* 218, 535 (1956).
6. Z. Dische and E. Bohrenfreund, *ibid.* 192, 583 (1951).
7. R. M. Hochster, *Can. J. Microbiol.* 1, 346 (1955); P. K. Stumpf and B. L. Horecker, *J. Biol. Chem.* 218, 753 (1956).
8. The gift of 6-deoxy-D-glucose tetraacetate from N. K. Richtmyer and the preparation of 6-deoxy-D-glucose therefrom by J. P. Shoffner are gratefully acknowledged. Further thanks are due G. C. Holsing for helpful suggestions on the isolation and characterization of D-fructose and to P. L. Gay for technical assistance.
9. Increased precision in the analysis for fructose by the cysteine-carbazole test has been obtained by heating the reaction mixture for exactly 10 minutes at 60°C instead of permitting the color to develop at room temperature.

14 January 1957

Neurogenic Inhibition of Shivering

The shivering that follows a fall in environmental temperature is known to originate in a region of the central nervous system above the spinal cord. Sherrington (1) showed that, in the dog with transected spinal cord, shivering occurred in those parts of the body that were above the level of the lesion and did not take place below the level of the transection. Dworkin (2) found that transection of the brain stem of the rabbit at the level of the calamus scriptorius decreased the intensity and changed the character of shivering markedly.

Shivering has been inhibited by raising skin temperature, by anoxia (3), by insulin (4), and by stimulating the hypothalamus (5). We have recently found that shivering elicited by administering Nembutal and lowering the skin temperature may be inhibited by stimulating nerves from skin or muscle (6).

Dogs and cats were used. The animals were anesthetized with Nembutal (25 mg/kg) intraperitoneally. To register shivering movements, a hind limb was attached by a rubber band to a phonograph crystal pickup, and the output of the crystal was led to an ink-writing oscillograph. In most cases it was necessary to initiate shivering by placing ice around the trunk of the animal. With the elastic system used, frequency of shivering was between 7 and 12 per second. The inhibitory stimulus was a 1-msec pulse from a thyatron oscillator whose output voltage and frequency could be varied.

A typical, consecutive series of shivering responses is shown in Fig. 1, as obtained from one animal. The effect of a 60-cy/sec stimulus applied to the skin of the contralateral limb of a cat is shown in Fig. 1a. Inhibition began immediately but did not continue after termination of the stimulus. In all properties tested, this inhibition resembled that studied by Sherrington in the decerebrate and spinal dog. The inhibition could be graded. Decreasing the intensity of the stimulus resulted in diminished inhibition (Fig. 1b). The degree of inhibition also depended on the frequency of stimulation. At 40 cy/sec (Fig. 1c), the inhibition was less than that obtained at 70 cy/sec (Fig. 1a). However, inhibition was obtained with strong single shocks when an exposed nerve was stimulated.

In several experiments, rebound occurred when the stimulus was terminated. Figure 1d shows the increased shivering that followed cessation of the stimulus. In most experiments, rebound, when present, was small.

Fatigue of the inhibitory system was also observed. When the inhibitory stimulus was prolonged for 10 to 20 seconds,

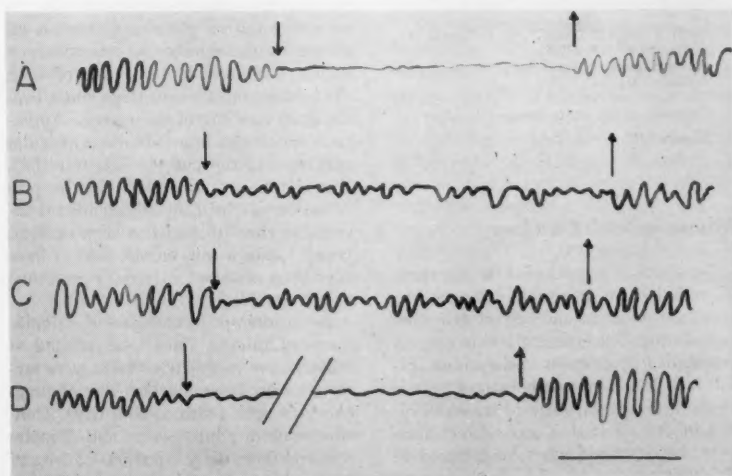


Fig. 1. Inhibition of shivering. Downward arrow marks onset and upward arrow marks termination of stimulus. Time (horizontal line) 1 second. Stimuli: (a) 70 v, 60 cy/sec; (b) 40 v, 60 cy/sec; (c) 70 v, 40 cy/sec; (d) 70 v, 60 cy/sec. Break indicates period of 3 seconds.

shivering commenced again as though the inhibitory system had been exhausted.

Inhibition of shivering was not limited to the segment where the stimulation was applied. No matter what region of body surface was stimulated, shivering stopped over the entire musculature of the animal. This can be observed visually or felt by the experimenter when a forelimb is held while the hind limb is stimulated.

The evidence indicates that inhibition of shivering takes place in a region of the nervous system located above the level of the spinal cord: (i) The simultaneous inhibition of the entire musculature suggests that the activity of a central region is being inhibited. (ii) Cutting the dorsal funiculi of the spinal cord at L2 resulted in an inhibition lasting for about 1 minute over the entire body. Thereafter shivering reoccurred. Severing the tracts acted as a stimulus which inhibited the central shivering mechanism. (iii) In several experiments, the dorsal region of the cord was cut at L2 so that shivering still occurred in regions of the body below the level of the section. Upon stimulation of the skin of a hind limb, however, inhibition of shivering did not take place either above or below the level of the section. Our interpretation of this result is that the centripetal passage of inhibitory impulses was blocked by dorsal section of the cord.

L. L. BOYARSKY
LAURINE STEWART

Department of Anatomy and Physiology,
University of Kentucky, Lexington

References and Notes

1. C. S. Sherrington, *J. Physiol.* 58, 26 (1924).
2. S. Dworkin, *Am. J. Physiol.* 93, 227 (1930).
3. A. C. Burton and O. G. Edholm, *Man in a Cold Environment* (Arnold, London, 1955), p. 154.
4. W. H. Finney, S. Dworkin, G. J. Cassidy, *Am. J. Physiol.* 80, 301 (1927).
5. A. Hemingway, P. Forgrave, L. Birzis, *J. Neurophysiol.* 17, 375 (1954).
6. This work was assisted by a grant from the University of Kentucky Research Fund.

22 January 1957

Mitosis in Adult Cartilage

Nowikoff (1) concluded from a study of cell division in amphibian cartilage that mitosis is the method of cell division during development but is entirely superseded by amitosis in the adult. Elliott (2) could not demonstrate mitosis in the articular cartilage of the extremities in the adult dog and rabbit; however, he described what he believed to be amitotic figures, which were presented in the form of a few questionable drawings. Clark and Clark (3) studied the formation of new cartilage in a transparent chamber that was installed

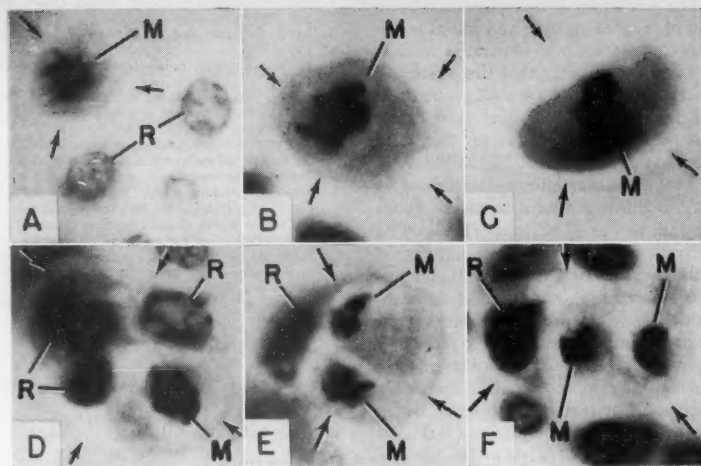


Fig. 1. Chondrocytes of adult symphyseal cartilage in mice following injections of estrogen, relaxin, and colchicine. Hyaline cartilage: A, D, and F ($\times 1000$); fibrocartilage: B and C ($\times 1500$), E ($\times 1000$). M, mitotic cell; R, "resting" cell; arrows, lacunar wall.

in the ear of a rabbit and found that fully differentiated chondrocytes did not divide when they were observed for several months. Most of the recent editions of American histology textbooks either state or intimate that division of fully differentiated chondrocytes, although quite rare, may occur. However, undoubtedly because of the controversial experimental evidence, nearly all fail to state whether cell division, if it does occur, is mitotic or amitotic.

In numerous studies on the pubic symphysis in mice, I have never observed a mitotic or amitotic figure in the interpubic chondrocytes of intact and untreated adult males and virgin females. However, the first changes which occur in the relaxation of the pubic symphysis, induced experimentally or occurring during pregnancy, are an increase in the number of chondrocytes within the individual lacunae of both the hyaline and fibrocartilage and a concomitant swelling of the matrix. Apparently no change occurs in other articular cartilages of the body at this time (4). The significance of mitosis in the proliferation of the fully differentiated interpubic chondrocytes has been unclear, because only a few mitotic figures have ever been observed in serially sectioned symphyses (4, 5).

In an attempt to elucidate the significance of mitosis, mice were treated as follows: five primiparous mice were sacrificed daily from the 12th day of pregnancy to term (19th to 20th day). Gonadectomized adult males and females received three daily injections of 1 μ g of estradiol benzoate in sesame oil, followed by an injection of 100 G.P. units of relaxin (6) in benzopurpurine. Two of each sex were sacrificed at 2-hour intervals from 6 to 48 hours following the

injection of relaxin. Each pregnant and gonadectomized mouse received an injection of 50 μ g of colchicine in saline 6 hours before necropsy to halt mitotic activity occurring during this interval at metaphase. Mitotic figures were increased 10 times in the symphyseal cartilage (9 to 10 average per section) when compared with identically treated mice that had not received colchicine (1 to 2 average per section). The mitotic activity was not localized in any particular area; however, as many as three mitotic figures were found in a number of individual lacunae of both the hyaline and fibrocartilage (Fig. 1). These findings cast great doubt on the occurrence of amitosis in cartilage, for nothing was found which I could even vaguely consider to be amitotic divisions.

E. S. CRELIN

Department of Anatomy,
Yale University School of Medicine,
New Haven, Connecticut

References and Notes

1. M. Nowikoff, *Z. wiss. Zool.* 90, 205 (1908).
2. H. C. Elliott, *Am. J. Anat.* 58, 127 (1936).
3. E. R. Clark and E. L. Clark, *ibid.* 70, 167 (1942).
4. E. S. Crelin and A. L. Haines, *Endocrinology* 56, 461 (1955).
5. K. Hall, *J. Endocrinol.* 5, 174 (1947).
6. Relaxin @ courtesy of R. L. Kroc, Warner-Chilcott Laboratories.
7. This work was aided by U.S. Public Health Service grant No. RG-4433(C).

29 November 1956

Effect of Kinetin on Protein Content and Survival of Detached Xanthium Leaves

When a leaf is detached from a plant, its protein content undergoes a prompt and rapid decline (1), the chlorophyll

content decreases in close proportion (2), and the life-span of the leaf is markedly reduced. Detached leaves are capable of incorporating labeled nitrogen and carbon into their protein (3, 4). Thus, their ability to synthesize protein is not altogether lost. However, they seem to have largely lost the ability to synthesize certain amino acids (4), and the ratio between protein synthesis and breakdown is greatly shifted in favor of the latter. Although this characteristic pattern of protein metabolism in detached leaves has led to extensive experimentation, attempts to modify it experimentally have not been successful.

In an attempt to control experimentally the survival and protein balance in detached leaves, we studied the effect of some plant regulators on these processes (5). Auxin (indole-3-acetic acid) sometimes reduced protein loss, but the effect was slight and erratic. Kinetin (6), in contrast, reduced protein loss in a consistent and striking manner.

The opposite primary leaves of young, vegetative *Xanthium pennsylvanicum* (cocklebur) plants were used in all experiments. Leaves that had reached full expansion or were quite close to reaching it were cut off and inserted with the petioles either into aqueous solutions of kinetin or into water. They were kept in bright, diffuse daylight and in a nearly water-saturated atmosphere (in glass-covered enamel trays) at a temperature of 22° to 25°C. The cuts were renewed every other day; the solutions, every fifth day.

Figure 1 shows the condition of the

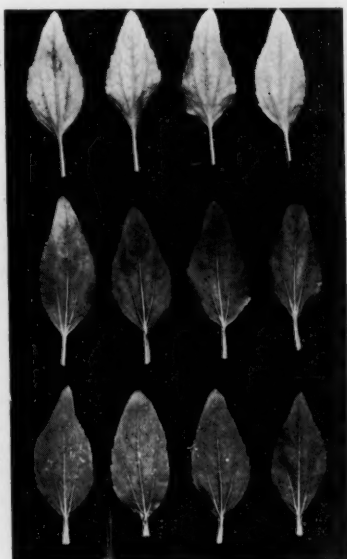


Fig. 1. Condition of detached *Xanthium* leaves after 10 days' culture on (from top to bottom) water, 1 mg of kinetin per liter, and 5 mg of kinetin per liter.

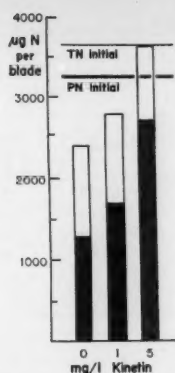


Fig. 2. Protein nitrogen (PN) and total nitrogen (TN) in detached *Xanthium* leaves (blades) after 12 days' culture on water and kinetin solutions. The total columns represent total nitrogen; the solid parts of columns represent protein nitrogen; and the horizontal lines show levels at the start of the experiment.

leaves at the end of an experiment. The leaves that were kept on water lost most of their chlorophyll, but those supplied with kinetin retained their green color.

Figure 2 shows the protein nitrogen and total nitrogen content of the leaf blades after an experimental period of 12 days. The blades of the controls lost 60 percent of their initial protein content. In the blades of leaves that were kept on 5 mg of kinetin per liter, the loss amounted to only 15 percent and was of the same magnitude as it is in attached leaves of comparable age. Leaves kept on 1 mg of kinetin per liter lost 50 percent of their protein. As has been found before (1), the protein nitrogen lost by the blades appears as soluble nitrogen in the petioles and the major veins. The amount of soluble nitrogen (measured as difference between total nitrogen and protein nitrogen) in the blades was about the same in controls and treated leaves.

The effect of kinetin on condition and protein content of detached *Xanthium* leaves has so far been somewhat variable. In one experiment, the treated leaves were still fully green after a period of 20 days, while the controls were completely yellow and were dying at the tip and margins. In other experiments, the difference in the survival period was smaller. This variability, which seems to depend on the age of the leaves and on the growing conditions of the plant, should have further investigation. However, there is no doubt that kinetin is capable of reducing or preventing the accelerated protein loss that is typical of detached leaves; at the same time, it delays the loss of chlorophyll and extends the life-span of the leaf. The former effect is very likely the immediate cause of the two latter.

Kinetin was discovered as a regulator of cell division (6, 7). However, several authors (8) found that kinetin promotes the growth of leaf discs, and this effect was based solely on cell enlargement. In the blade of kinetin-treated, detached *Xanthium* leaves, new cell division cannot be observed either. Cell-division activity thus does not seem to be a premise for the effects of kinetin on the growth of leaf tissue and on its protein metabolism. Whether the last-named effect is an essential feature of the action mechanism of kinetin in growth responses will have to be decided in future work.

AMOS E. RICHMOND*
ANTON LANG

Department of Botany,
University of California, Los Angeles

References and Notes

1. A. C. Chibnall, *Protein Metabolism in Plants* (Yale Univ. Press, New Haven, Conn., 1939), chap. 8; J. Bonner, *Plant Biochemistry* (Academic, New York, 1950), chap. 20.
2. G. Michael, *Z. Botan.* 29, 385 (1935).
3. A. C. Chibnall and G. H. Wiltshire, *New Phytologist* 53, 38 (1954).
4. D. W. Racusen and S. Aronoff, *Arch. Biochem. and Biophys.* 51, 38 (1954).
5. This work was in part supported by research grants from the National Institutes of Health, U.S. Public Health Service (RG-3939) and the University of California Cancer Research Coordinating Committee (grant Nr. 407).
6. C. O. Miller *et al.*, *J. Am. Chem. Soc.* 78, 1375 (1956).
7. N. K. Das, K. Patai, F. Skoog, *Physiol. Plantarum* 9, 640 (1956).
8. C. O. Miller, *Plant Physiol.* 31, 318 (1956); S. Kuraishi and F. S. Okumura, *Botan. Mag. (Tokyo)* 69, 300 (1956).

* Present address: P.O.B. 4816 (c/o Dr. Fenichel), Haifa, Israel.

17 January 1957

Temperature-Respiration Curve of Flour Beetles Exposed to Nonoptimal Temperatures

The ability of various species of poikilotherms to adapt to temperatures above or below their normal temperature range is well known (1). The adaptation may or may not be accompanied by a change in metabolic regulation (2). Bělehrádek (3) has shown that temperature coefficients often increase with protoplasmic adaptation to a higher temperature. Respiratory compensation in poikilotherms at subnormal temperatures is evidenced by a higher oxygen consumption, at any given temperature, compared with that of the organism at its normal environmental temperature. In supranormal temperatures, compensatory respiration is depressed (1).

The work described here represents a portion of a study made to determine the factors influencing the effects of temperature on adult flour beetles, *Tribolium confusum* Duval (4). The insects were taken from a culture kept at 30°C which has been maintained in our laboratory for 10 years. The food medium

Table 1. Respiration curve constants, with 95-percent confidence limits, for *T. confusum* with three different previous temperature histories.

Previous temperature (°C)	Constant	Females		Males	
		Value	Confidence limits	Value	Confidence limits
30	log <i>a</i>	-1.856	± 0.098	-1.968	± 0.125
30	<i>b</i>	1.490	± 0.072	1.540	± 0.092
18	log <i>a</i>	-2.707	± 0.204	-2.959	± 0.199
18	<i>b</i>	2.008	± 0.174	2.124	± 0.169
38	log <i>a</i>	-2.868	± 0.151		
38	<i>b</i>	2.002	± 0.128		

was whole wheat flour plus 3 percent of ground wheat germ. A large sample of insects aged at least 2 months from pupal emergence was placed in a constant-temperature cabinet at 18° ± 1.5°C, while a similar sample was placed in a cabinet 37.5° ± 1°C. All cultures were kept at 75-percent relative humidity. The insects were kept at the abnormal temperatures for a number of months, and larvae were continually removed so that the age of the insects was known.

Respiration determinations were made with Barcroft respirometers (5) in a constant-temperature bath. Ten insects of one sex were introduced into the manometer cup with small flour-paper strips. They were allowed to recover from the effects of handling for 24 hours prior to use. A series of measurements of oxygen consumption was made, using fresh insects for each experiment, between temperatures of +5° and +44°C. Determinations were made for males and females that had been kept at 30° and 18°C and for females that had been kept at 38°C. Five readings for oxygen

consumption were made at each temperature.

The data obtained were found to fit a straight line when the logarithms of both variables were plotted. The regression line was fitted by the method of least squares and tested for goodness of fit by an analysis of variance and an *F* test. The lines of best fit for females have been expressed in semilogarithmic form in Fig. 1. The equation that best describes the data obtained between the temperature limits used is

$$y = ax^b$$

or

$$\log y = \log a + b \log x$$

where *y* is oxygen consumption in cubic millimeters per milligram, per hour and *x* is the temperature in degrees Centigrade.

The respiration curve for insects from both 18° and 38° temperatures is depressed below the curve for 30° insects. The values of the constants log *a* and *b* for the insects taken from the three experimental temperatures are given in Table 1. For the insects that were kept at the nonoptimal temperatures 18° and 38°C, *a* is significantly lower and *b* is significantly higher than the corresponding values obtained for insects kept at 30°C. However, corresponding constants for the 18° and 38° groups are not significantly different. The inverse relationship between the constants *a* and *b* when the previous temperature history is changed is the result of the curves' approaching a similar value for oxygen consumption at the maximum temperature. The log-log line "rotates" about the maximum value, thus resulting in an inverse relationship between the slope (*b*) and the intersection of the line with the vertical axis (log *a*).

Insects kept at 18°C increased in weight, although they had been originally put at this temperature as fully mature adults. Insects kept at 38°C lost weight. Regression of oxygen consumption on weight was not, however, sufficient to account for the differences in the *T-R* curves.

It seems probable that the apparent similarity between the 18° and 38° groups is superficial, the depression of the over-all metabolic rate of the latter being the result of heat injury, while depression of the 18° curve represents a depression of the metabolic rate without injury to the metabolic systems. This is suggested by the fact that the activity and general behavior of the 38° group appeared slow and poorly coordinated, while that of the 18° insects was normal, and indeed seemed more vigorous when the insects were disturbed.

Samples of insects from the three experimental temperatures were kept at -3° ± 1°C, relative humidity 75 percent. Two days' exposure was sufficient to kill approximately 90 percent of those that had been acclimatized at 30°, while approximately 1 percent of the 18° insects were killed. All 38° insects were killed in 2 days. Males were found to have a statistically greater survival ability than females at this temperature.

Samples of insects from the three temperatures were kept at 40°C, relative humidity 75 percent. Eighty-four percent of 30° and 82 percent of 18° insects were killed in 6 days, while all 38° insects were killed in 6 days. There was no statistical difference between the survival abilities of females and males.

The curve data show a nonstatistical difference between the constants obtained for males and females of the same temperature group. There is, however, a trend in the direction of a greater oxygen consumption per unit weight in females. This difference, reported previously (6), cannot be considered significant.

It is concluded that, under the conditions described in the preceding paragraphs, respiratory adaptation to non-optimal temperatures does not occur in *Tribolium confusum*, while the ability to survive at low temperatures may be enhanced by low-temperature adaptation (7).

DONALD K. EDWARDS

Department of Zoology, McGill University, Montreal, Quebec

References and Notes

1. T. H. Bullock, *Biol. Rev.* 30, 311 (1955).
2. P. K. Rao and T. H. Bullock, *Am. Naturalist* 88, 33 (1954).
3. J. Bělehrádek, *Publ. Med. Fac. Brno. C.S.R.* 9, 81 (1930).
4. D. K. Edwards, Thesis, McGill University. The financial support of the National Research Council of Canada is gratefully acknowledged.
5. I am indebted to the department of biochemistry, McGill University, for valuable aid in this work, and to G. I. Paul of the department of genetics, who gave much of his time in advising on the statistical analysis. Thanks are also due to J. Stanley, chairman of the department of zoology, for the use of his insect cultures and constant-temperature equipment.
6. T. Park, *J. Cellular Comp. Physiol.* 7, 313 (1936).
7. A description of further results obtained in connection with this study is in preparation.

14 January 1957

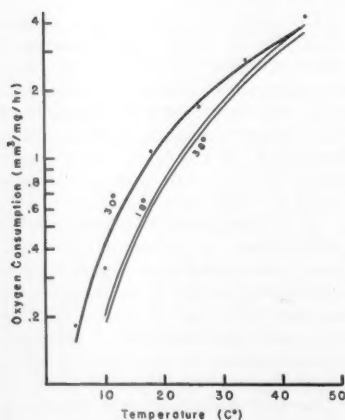


Fig. 1. Semilogarithmic temperature-respiration curves of adult, female, *T. confusum* with three different previous temperature histories. Each point represents the mean of five values for oxygen consumption of 30° insects at each experimental temperature.

Book Reviews

Physical Methods in Chemical Analysis. vol. III. Walter G. Berl, Ed. Academic Press, New York, 1956. \$15.

The practice of quantitative analysis is based on the measurement of properties. The field of analytical chemistry is continuously expanding as new molecular, atomic, nuclear, and other subatomic properties are being discovered. This expansion is further implemented by the phenomenal progress—especially since World War II—in the field of instrumentation. This is evidenced by the development of a large number of new instruments, which make possible rapid and accurate measurement not only of classical (optical, electric, and so forth) properties but also of newly discovered properties. The expansion of analytical chemistry is so vast that it becomes impossible for any individual to master the theoretical and experimental progress in his field. Even an expert in a limited domain can hardly digest all the new developments published in the numerous journals all over the world. The rapid expansion of quantitative analysis and the immense literature demand that up-to-date descriptions of newly developed and modernized classical techniques be available.

Volume III of *Physical Methods in Chemical Analysis*, like the two previous volumes, satisfies such a demand. The first article, on gas chromatography, gives a thorough survey of the subject in 28 pages. It could be made more useful by a brief introductory statement of what gas chromatography is, what type of experimental technique is used, and what can be accomplished. A similar comment can be made on some of the other articles. Space does not permit a review of each article in detail. The following diverse topics, in addition to gas chromatography, are presented: electrochromatography (36 pages), electroanalytic methods in trace analysis (34 pages), high-frequency method of chemical analysis (26 pages), field emission spectroscopy (46 pages), theory and principles of sampling for chemical analysis (32 pages), flame photometry (56 pages), microwave spectroscopy (20 pages), analytic applications of nuclear magnetic resonance (75 pages), fluores-

cent x-ray spectrometric analysis (14 pages), analytic distillation (43 pages), neutron spectroscopy and neutron interactions in chemical analysis (170 pages).

All the chapters are written by experts and cover the topics adequately. Even though the entire field continues to expand rapidly, many chapters will be of lasting value, because they present the fundamentals of the subject in a very thorough way.

The editor has maintained his policy, which is to present a review of the status of physical measurements and their application as analytic tools. This volume is a valuable addition to the literature and will be appreciated, not only by analytical chemists, but by all scientists who use new techniques in their research.

I. M. KOLTHOFF

University of Minnesota

Principles of Zoology. John A. Moore. Oxford University Press, New York, 1957. 667 pp. Illus. \$7.50.

Only an experienced and talented teacher could have written a book like this, which fills the needs of so many students in the biological sciences. John Moore's literary and pictorial treatment of the principles of zoology is by far the most efficient ever put into book form.

This book is divided into six parts: "General features of a biological system"; "The development of genetic concepts"; "Embryology"; "Evolution"; "Human physiology"; "The philosophy of science."

Moore writes with a high purpose of mind that "biology today is very different from what it was fifty or a hundred years ago, and we should humbly admit that it probably will be very different fifty or a hundred years from now." He makes no tacit assumptions and spells out the soundest principles of biology and zoology.

The first part of this book includes an explanation of the general features of biological systems. The author provides examples ranging from unicellular animals (amebas) to multicellular animals

(with special reference to the frog). Included in this section is a description of the invertebrate phyla. Classical examples of all the important invertebrates are cited and shown pictorially.

In the second part the author follows the development of genetics in an illuminating manner. This section elucidates the following carefully: Darwin's theory of pangenesis; the cell and its division; fertilization and gamete formation; the nucleus and heredity; Mendel, Boveri, and Sutton; sex chromosomes; variations in Mendelian ratios; Morgan's white-eyed *Drosophila*; linkage and crossing over; mapping the genes; genes on the chromosomes; multiple alleles; induced mutations; salivary gland chromosomes; and the basic concepts of classical genetics. The genetic process is made very clear for the student, and in a world where there are so many children being born every minute, this carefully put together section will be of tremendous value for students and laymen alike.

The section on embryology is quite complete. Numerous illustrations document the text, and the combination of words and well-chosen illustrations leaves nothing to be desired in the way of information at the student level.

In the fourth section, on evolution, Moore gives a scholarly analysis of the views of Charles Darwin. Teacher and student, alike, will enjoy the author's account of the way in which Darwin's theory was formulated. Furthermore, the very practical reference to Darwin's "trumpery" feelings, as revealed in his letters to Sir Charles Lyell, will add a great deal of interest for students. The crowning achievement of this section is the author's able résumé of the process and dynamics of evolution, the changes in gene frequency, the patterns of evolution in animals, chromosome changes and species formation in plants, and finally the origin of life.

These four sections provide the student with a wealth of information for understanding human physiology. That the author is an able teacher is well demonstrated in his approach to a careful series of demonstrations designed to elucidate physiological mechanisms.

Finally, the last section, on "Science and its methods," is an honest statement of what we really know and, more important, of the amount of information we lack. James B. Conant will be delighted to see the fruits of his many years of labors [see *Science and Common Sense* (Yale University Press)] realized in the form of an excellent textbook that makes biology an inspiring, rewarding, and meaningful approach to an understanding of hitherto seemingly complex phenomena.

This book will be welcomed by both teachers and students. It is clearly writ-

ten, is beautifully illustrated, and not only will hold the interest of students but, I feel confident, will stimulate their desire for more information from specialized courses in biology. This book is a fine contribution; the author and publisher are to be congratulated for the publication of a very useful textbook of zoology.

JOSEPH T. VELARDO
Yale University School of Medicine

Research in the Effects and Influences of the Nuclear Bomb Test Explosions.

pts. I and II. Committee for Compilation of Reports on Research in the Effects of Radioactivity. Japan Society for the Promotion of Science, Ueno, Tokyo, 1956 (order from Stechert-Hafner, 31 East 10th St., N.Y.). 1824 pp. Illus. \$25.

The test explosion of a thermonuclear weapon at Bikini Atoll in March 1954 resulted in a major effort on the part of Japanese scientists to measure the spread of radioactive fission products and to assess the nature of the effects on man and his environment. The results of this work have been published in a two-volume report containing more than 200 papers. Included among these are also some papers related to the delayed effects of injuries sustained at the time of the Hiroshima and Nagasaki explosions in August 1945. The subjects dealt with are meteorology, physics, chemistry, genetics, agriculture, fisheries science, economics, and medical science.

In addition to a large number of papers dealing with the measurement of activity in rain, snow, and sea water, the meteorology section includes a comparison of the efficiency of the air impinger and electrostatic precipitator as "particulate" collectors. The members of the "Japanese Bikini Expedition" were given the task of surveying the waters around Bikini and near Japan and were able to show that some of the radioactivity was transported by air but that most of it moved in the North Equatorial Current. Included are some interesting observations of pressure waves from the 1952 and 1954 explosions, from which both the total energy release and the time of firing of the weapon are calculated, using the amplitude and the velocity of propagation of the wave.

The physics section is concerned largely with studies of contamination found on the Japanese fishing vessel No. 5 "Fukuryu Maru," though a few papers deal with physical properties of the particles. A complete survey was made of the ship, and from this the integrated dose to crew members was estimated. This is, of course, invaluable information when it is combined with the results of

the medical studies. Also included are details of the locations of most of the Japanese fishing vessels during the Bikini trials in relation to the contamination found on them subsequently. Numerous methods were used to investigate the physical properties of the ash, which was shown crystallographically to be calcite granules with a diameter of 0.3 millimeter, presumably recrystallized from the vaporized coral reef.

Much of the chemistry section deals with qualitative radiochemical analyses of this material, together with an investigation of the fission-product content of the organs of the crew member who died. It is of interest that in addition to the fission products, several of the actinide elements were detected in air-borne material by the chemists, who also reported the absence of activities other than those arising directly in the fission process. Some discussion of the physical significance of these findings is included.

The genetics section consists almost entirely of descriptions of the mutations and chromosome abnormalities appearing in the descendants of crop plants and weeds which survived the Hiroshima and Nagasaki explosions. The most conclusive finding was a tenfold increase in genetic abnormalities in rice plants grown from seeds gathered within 600 meters of the hypocenter at Nagasaki. The dose is not estimated, but, from the human mortality data reported elsewhere, it was probably much greater than 500 roentgens.

The agriculture section gives extensive information on the contamination of trees, plants, animals, soil and water, as a result of the Hiroshima, Nagasaki, and Bikini explosions, together with a brief description of the injuries sustained by animals in Hiroshima. Unfortunately, many of the data on contamination are difficult to interpret, because in most cases only the shorter lived nuclides—for example, strontium-89 and barium-140—are measured, and in many instances the results are given in counts per minute.

The fisheries science section is one of the most extensive and is concerned primarily with measurements of the radioactivity found in the fish caught commercially between Japan and Bikini following the 1954 explosion. It is of interest that a radioisotope, zinc-65 (which is not an important fission product and was not reported in the air-borne contamination) was widely distributed in sea life. Most of these reports, however, were written before a full chemical analysis had been carried out. Included also are descriptions of what are probably the most detailed experiments so far reported, on absorption both of mixed fission products and of radioisotopes of strontium, calcium, and zinc by aquatic animals. The serious effects of the publicity associated with the possibility of radioactive contamination of fish is dealt with in the

economics section, where the plight of the workers in the industry is vividly described.

The medical science section contains the best and most detailed work in the report. This is probably due to the fact that the Atomic Bomb Injuries Investigation Research Committee had been working since 1953 on systematic investigations of the results of the Hiroshima and Nagasaki explosions, its membership merely being extended following the Bikini accident. The collection of papers presented is a book in itself. It starts with a description of the events which befell the "Fukuryu Maru" before dawn on the morning of 1 March 1954, reviews the early clinical features of the radiation injuries in her 23 crewmen, deals in detail with the later hematological, pathological, histological, and bacteriological observations, and includes the autopsy findings on the one fatality which occurred 6 months later (although it is not certain that the death was caused by the exposure). It is estimated that the crew probably received an accumulated exposure of from 270 to perhaps as much as 440 roentgens of external radiation during the 2 weeks which it took the "Fukuryu Maru" to return to its home port of Yaizu.

In assessing the scientific value of these volumes one should not lose sight of the difficulties which must have been associated with the collection of such a bulk of descriptive material. It is true that the individual contributions show little apparent attempt at integrating the final report into a cohesive whole, that there is sometimes a lack of control observations where one would wish them, and that the measurements of radioactivity can often be translated only very roughly into standard units. It is much more important, however, that this extensive and diverse material did in fact get collected and brought together into a single publication. The task of extracting and co-ordinating the information into a more readily assimilable form has yet to be carried out, but it might never be undertaken if the descriptions had not been gathered together in the present volumes.

C. A. MAWSON

H. B. NEWCOMBE

W. E. GRUMMITT

Atomic Energy of Canada, Ltd.

Physics. John S. Marshall and Elton R. Pounder. Macmillan, New York, 1957. 906 pp. Illus. \$8.50.

A survey of the many introductory physics texts that have appeared recently and a glance at the direction in which established texts have evolved reveals that the emphasis has been upon including a greater number of topics and

applications. To what extent breadth of knowledge can be achieved in an introductory physics course without sacrificing depth of insight into the fundamental physical principles and an appreciation of the logical coherence of the subject is debatable. Certain it is, however, that when, as in this textbook, the emphasis on various topics is not a particularly happy balance, the results are unfortunate. Chapters are devoted to such topics as the special theory of relativity, the wave-particle duality of wave mechanics, and nuclear physics. Yet one finds a very abbreviated section on electrostatics which contains no mention of Gauss' theorem and very little explanation of the behavior of a dielectric. As a result, the text is forced merely to state the capacitance of a parallel plate capacitor, prefaced only with the remark, "It can be shown that . . ." This is hardly adequate for a text which is described in the preface as containing sufficient material for a 2-year course.

Viewed as a textbook for a 1-year course, the book has many commendable features. The method of presentation is conversational, often humorous, with many clear and simple figures and graphs to illustrate the text material. A few topics are treated in a refreshingly direct and detailed way that is unusual for a textbook at this level. For example, the relationship between torque and angular acceleration is proved for a rigid body by a direct application of Newton's second law, rather than from conservation of energy. The section on heat, similarly, uses detailed yet clearly presented approaches to the kinetic theory of ideal gases, the Carnot cycle, the thermodynamic definition of temperature, irreversibility, and so forth.

The only mathematics required to read the book are algebra and trigonometry, although at the end of each chapter is a section which gives the derivation by calculus of some of the principal results. However, this method of presenting applications of calculus is scarcely likely to impress the reader with the advantages of knowing and using this tool. Vectors are also discussed at the beginning of the book in order to make such concepts as force and velocity clear. Unfortunately, the discussion of a vector is completely at variance with the definition to be found in all other physics and mathematics texts with which I am familiar. Vectors are said to have direction and magnitude, but it is stated that the method of addition for specific vectors can only be determined by experiment.

In my opinion, however, these advantages are more than offset by the superficial treatment of most other basic topics. The use of a very informal but uneconomical style makes it impossible for the authors to provide adequate back-

ground for the large number of topics and applications introduced in the book. In the chapter on angular motion, for example, the vector character of angular velocity is introduced without any attempt to give either a logical or an intuitive justification for the choice. The rate of precession of a gyroscope is then "derived," and a section follows on applications of the gyroscope in various aircraft instruments. Again, in the chapter on fluid mechanics, one finds a page on the air-speed indicator for aircraft. Yet Bernoulli's principle merely is given as a statement that "In a streamline flow, the pressure is greatest where the velocity is least." There is no attempt at a derivation, or even an explicit formula. The whole discussion of the principle is limited to a remark on the lift on an aircraft wing and a paragraph on the motion of a golf ball. This approach to introductory physics is likely to encourage the tendency of students to acquire a glib familiarity with the facts rather than an appreciation of their significance and a real understanding of the physical principles.

WILLIAM M. MACDONALD
University of Maryland

New Books

Wind and Solar Energy. Proceedings of the New Delhi Symposium. vol. VII of *Arid Zone Research*. 1956. 238 pp. \$8. *Human and Animal Ecology.* Reviews of research. vol. VIII of *Arid Zone Research*. 1957. 244 pp. \$5. UNESCO, Paris.

Le Ciel et la Terre. vol. III of *Encyclopédie Française*. André Danjon, Pierre Pruvost, Jules Blache, Directeurs. Société Nouvelle de l'Encyclopédie Française, Paris, 1956.

The People of Puerto Rico. A study in social anthropology. Julian H. Steward, Robert A. Manners, Eric R. Wolf, Elena P. Seda, Sidney W. Mintz, Raymond L. Scheele. University of Illinois Press, Urbana, 1956. 540 pp. \$10.

Principles of Engineering Geology and Geotechnics. Geology, soil and rock mechanics, and other earth sciences as used in civil engineering. Dimitri P. Krynine and William R. Judd. McGraw-Hill, New York, 1957. 730 pp. \$10.

Allgemeine Meereskunde. Eine Einführung in die ozeanographie. Günter Dietrich. Gebrüder Borntraeger, Berlin, 1957. 492 pp. DM. 56.

The Species Concept in Palaeontology. A symposium. Publ. No. 2. P. C. Sylvester-Bradley, Ed. Systematics Assoc., London, 1956. 145 pp. \$2.

How to Know Western Australian Wildflowers. pt. II, *A Key to the Flora of the Temperate Regions of Western Australia.* William E. Blackall and Brian J. Grieve. University of Western Australia Press, Nedlands, 1956. 138 pp. 30s.

Analog Computers, Their Industrial Applications. Proceedings of a Symposium for Management. Midwest Research Institute, Kansas City, Mo. 1957. 210 pp. \$5.

Man and Society. The basic teachings of sociology. Samuel Koenig. Barnes & Noble, New York, 1957. 399 pp. Paper, \$1.45.

Botany. A laboratory manual. T. E. Weier, C. R. Stocking, J. M. Tucker. Wiley, New York; Chapman & Hall, London, ed. 2, 1957. 175 pp. \$2.95.

Heat and Thermodynamics. An intermediate textbook for students of physics, chemistry, and engineering. Mark W. Zemansky. McGraw-Hill, New York, ed. 4, 1957. 484 pp. \$7.50.

About Mice and Man. An introduction to mammalian biology. Frederick R. Avis. J. Weston Walch, Box 1075, Portland, Maine, 1957. 194 pp. \$3.

Elements of Engineering Thermodynamics. Rolf H. Sabersky. McGraw-Hill, New York, 1957. 318 pp. \$7.50.

Dynamic Meteorology and Weather Forecasting. C. L. Godske, T. Bergeron, J. Bjerknes, R. C. Bundgaard. American Meteorological Society, Boston; Carnegie Institution, Washington, 1957. 800 pp.

Die Saftströme der Pflanzen. Bruno Huber. Springer, Berlin, 1956. 126 pp. DM. 7.80.

Optics. Bruno Rossi. Addison-Wesley, Reading, Mass., 1957. 510 pp. \$8.50.

Stress and Strain in Bones. Their relation to fractures and osteogenesis. F. Gaynor Evans. Thomas, Springfield, Ill., 1957. 245 pp. \$6.50.

Pica. A survey of the historical literature as well as reports from the fields of veterinary medicine and anthropology, the present study of pica in young children, and a discussion of its pediatric and psychological implications. Marcia Cooper. Thomas, Springfield, Ill., 1957. 114 pp. \$3.75.

Experiments with a Microscope. Nelson F. Beeler and Franklyn M. Branley. Crowell, New York, 1957. 154 pp. \$2.75.

Directory of Institutions Engaged in Arid Zone Research. UNESCO, Paris, 1953. 110 pp. \$1.50.

Discoveries and Opinions of Galileo. Translated by Stillman Drake. Doubleday, Garden City, N.Y., 1957. 302 pp. \$1.25.

Communism on the Decline. George C. Guins. Philosophical Library, New York, 1956. 287 pp. \$7.50.

Techniques of Organic Chemistry. vol. III, pt. II, *Laboratory Engineering*, Arnold Weissberger, Ed. Interscience, New York, ed. 2, 1957. 391 pp. \$8.

Epidemiology. Bull. World Health Organization, vol. 15, No. 1-2. 359 pp. \$4.

Malaria. Eradication, insecticide resistance, entomological investigations, epidemiology, control prophylaxis. Bull. World Health Organization, vol. 15, No. 3-5, 502 pp. \$6. World Health Organization, Geneva, 1956.

Annotated Bibliography of Works in Latin Alphabet Languages on Biological Microtechnique. Freda Gray and Peter Gray. Brown, Dubuque, Iowa, 1956. 116 pp. \$3.

Christian Theology and Natural Science. Some questions on their relations. E. L. Mascall. Ronald Press, New York, 328 pp. \$4.50.

The Negro in the United States. E. Franklin Frazier. Macmillan, New York, rev. ed., 1957. 769 pp. \$6.40.

Meetings and Societies

Clinical Chemistry

Approximately 700 clinical chemists, representing 34 countries, attended the International Congress of Clinical Chemistry held in New York, 9-14 Sept. 1956. The congress was held under the auspices of the American Association of Clinical Chemists, by authorization of the International Federation of Clinical Chemistry and the Commission on Clinical Chemistry of the International Union of Pure and Applied Chemistry.

Through the good offices of the National Science Foundation and 14 members of the American chemical industry, the American Association of Clinical Chemists was able to invite and partially subsidize the travel expenses of 30 foreign scientists. Many of these foreign scientists participated in the five symposia. In addition to these invited guests, there were official representatives of the various foreign scientific societies and of both foreign and United States government agencies.

The 17 scientific sessions at which 120 contributed papers were presented, were designed around the five symposia, on "Electrolytes," "Porphyrins," "Standardization," "Enzymes," and "Proteins." The symposia and contributed papers contained a wealth of material; limited space prohibits detailed discussion of all of it here. Abstracts of the scientific papers appeared in *Clinical Chemistry* (August and December 1956). The American Association of Clinical Chemists has arranged for publication of all 20 of the invited papers which comprised the symposia, as a supplement to volume 3 of *Clinical Chemistry*, the official journal of the association.

Harry Sobotka, chairman of the Scientific Program Committee, initiated the first of the scientific sessions by introducing Donald D. Van Slyke (Brookhaven National Laboratory), who opened the symposium on blood electrolytes by paying tribute to a pioneer of the science in "Appreciation of the contribution to clinical chemistry by the late Dr. John P. Peters." His talk was followed by discussions of the blood electrolyte problem by C. P. Stewart (University of Edinburgh) and R. Margaria (Univer-

sity of Milan). J. R. Elkinton (University of Pennsylvania) discussed the role of magnesium in body fluids.

The session entitled "Serum proteins in hepatic diseases" featured eight papers on serum flocculation phenomena in both normal and hepatic disease states. E. M. Greenspan (Mt. Sinai Hospital, New York) showed that the fractional assay of the serum globulins may be helpful in the diagnosis of medical, as distinguished from surgical, jaundice.

M. H. Power (Mayo Clinic) presented a rapid procedure for the turbidimetric estimation of potassium in biologic fluids, in which tetraphenylboron is used as a reagent. This procedure is suited for easy detection of abnormal blood potassium levels when a flame photometer is not readily available. In "Electrolyte disturbances in acute uremia," J. Hamburger (Hôpital Necker, Paris), presented data on 60 anuric patients both before and after dialysis with an artificial kidney. His excellent presentation was followed by talks by R. Neher (Basle, Switzerland) and B. Josephsen (St. Erik's Hospital, Stockholm), who discussed "Blood electrolytes under the influence of cortical hormones," and "Fluid compartments and the excretion of electrolytes," respectively.

A number of papers discussed the use of enzymatic tests for the detection of glucose in urine. The investigators utilized the enzyme system, glucose oxidase and horse-radish peroxidase in the presence of *o*-toluidine. The presence of glucose is detected by the formation of a blue color when paper strips, impregnated with this enzyme system, are dipped in a solution containing glucose. The data showed that the test is specific for glucose, with a sensitivity of less than 0.1 percent.

The session on instrumentation featured the presentation by L. T. Skeggs (Western Reserve University), who presented his development of an instrument for automatic colorimetric analysis. This has a recording flow-cell colorimeter, a continuous dialyzer, and an automatic continuous arrangement for addition of reagents. It can run 20 to 30 analyses per hour and has been adopted for the determination of blood urea, calcium, and glucose. The analytic results com-

pare favorably with those obtained by conventional methods.

D. E. Duggan (National Heart Institute, Bethesda, Md.) presented "Spectrophotofluorometry, a new tool for analysis at the submicrogram level." Other papers presented the adaptation of routine macro procedures to micro-analysis.

R. Schmid (National Institutes of Health, Bethesda, Md.) discussed data showing that bilirubin glucuronide is the compound that reacts directly with diazotized sulfanilic acid. The nonconjugated bilirubin, owing to its insolubility in water below a pH of 8, will react with the diazotized reagent only after the addition of alcohol. T. H. J. Huisman (Groningen, the Netherlands) discussed the properties, estimation methods, hematologic features, and certain aspects of abnormal human hemoglobins.

Contributed papers on enzymes presented data on tributyrinase, cholinesterase, and aldolase activity in blood. Increases of serum acid phosphatase levels in cases of Gaucher's and Niemann-Pick disease were reported. The clinical significance of alterations in the serum transaminases and simplified procedures for the determination of this activity as a test for myocardial infarction and hepatic damage were presented.

The symposium on "Standardization" featured talks by I. D. P. Wootton (University of London), D. Seligson (University of Pennsylvania), M. Guillot (University of Paris) and M. C. Sanz (University Hospital, Geneva) and covered the problem of standardization of clinical chemical procedures on an international scale. The resolution of the standardization problem through the use of a "standard serum" was discussed as well as new basic ultramicro equipment covering all phases, from specimen collection to precise automatic reagent delivery.

An evaluation of trends in electrophoresis instrumentation was presented by A. Henley (National Instrument Laboratories, Riverdale, Md.). Henley pointed out the many contributions made by the late Kurt G. Stern to the development of compact, practical, moving-boundary electrophoretic apparatus. M. Reiner (D.C. General Hospital, Washington) spoke on the personal character of Stern, emphasizing especially the infectious enthusiasm for science which he imparted to his graduate students. N. F. MacLagan (Westminster Medical School, London) discussed the value of mucoprotein estimations in clinical chemistry. He pointed out that, in general, serum mucoprotein estimations are preferred to those on urine. The results obtained in cancer, inflammations, and in liver and collagen diseases were reviewed. The relationship

between the mucoprotein levels and flocculation tests and liver function were also discussed.

Z. Stary (Istanbul University) developed further the role of mucoproteins in clinical chemistry. He discussed the large number of pathologic conditions and the accompanying changes which are observed in the level of the protein-bound carbohydrates. The last paper of the symposium was presented by J. C. M. Verschure (State University, Utrecht, the Netherlands). He spoke on the significance of lipoproteins in clinical chemistry and emphasized the role of lipid diagrams obtained by paper electrophoresis. Verschure summarized and discussed, from a critical standpoint, the rich new literature in this field and pointed out some of the limitations and possibilities of the technique for the clinical laboratory.

The session on "Lipoid analysis and lipoproteins" presented new methodology for the study of blood cholesterol (R. Jonnard, Paterson General Hospital, New Jersey) as well as for fats and fatty acids. H. P. Schwarz (Philadelphia General Hospital) discussed data on infrared analysis of tissue lipids, serum glycoproteins, lipoproteins, and lipoprotein constituents.

The diabetogenic action of xanthurenic acid was reported by Y. Katake (Wakayama Medical College, Japan) in two papers presented at the symposium on "Enzymes." This session also featured a discussion of B-complex vitamins by N. Siliprandi (University of Camerino, Italy), one on products of the citric acid cycle, by Jo Nordmann (Paris), and a paper entitled "Significance of enzymes in clinical chemistry," by E. J. King (Postgraduate Medical School, London).

Newer methodology for the study of inorganic blood constituents and their relation to health and disease was discussed in many contributed papers in the sessions devoted to this subject. Studies of improved volumetric and colorimetric procedures for calcium, as well as studies on calcifying mechanisms and bone-bank preservation, were discussed. I. Sunshine (Cleveland, Ohio) presented data showing the value of barbiturate analysis for the differential diagnosis of a comatose patient. Micro procedures for the determination of ammonia in biologic fluids were given by Seligson, and the problem of specificity in the determination of urinary catecholamines was discussed by W. B. Mason (University of Rochester).

E. Heftmann (National Institutes of Health) presented his method for the determination of individual adrenocortical steroids in urine by use of silicic acid columns and assay by ultraviolet absorption and tetrazolium blue reduc-

tion. R. E. Peterson (National Institutes of Health) reported that his group had developed a method of assay for plasma corticosterone based on the principle of isotope dilution, in which corticosterone-4-C¹⁴ was used. Data from a variety of clinical syndromes which suggest that the urinary potassium/sodium ratio parallels endogenous aldosterone activity were discussed by C. L. Fox, Jr. (New York Medical College).

The hard-working committees appointed by the AACC and the host, the Metropolitan-New York Section, were responsible for the success of the congress. The scientific program, exhibits, and social events scheduled by Albert E. Sobel, congress chairman, John G. Reinhold, congress secretary, and So-botka, scientific program chairman, and by members of the exhibit and hospitality committees made the congress an outstanding scientific event.

HAROLD D. APPLETON
Metropolitan Hospital, New York

American Nuclear Society

The American Nuclear Society, which is composed of scientists and engineers interested in nuclear science and technology, held its first winter meeting in Washington, D.C., 10-12 Dec. 1956. Most of the 22 sessions dealt rather directly with reactor problems, including those of theory, kinetics, physics, engineering, and plant design. Related sessions were on "Health physics and radiobiology," "Chemistry and metallurgy," and "Experimental techniques and instrumentation." These sessions were of great interest to those active in the nuclear-power area. However, a comprehensive summary is beyond the scope of this report.

One meeting highlight was a session of invited papers on "Thermonuclear reactions," chaired by T. H. Johnson (Atomic Energy Commission). Speakers included R. F. Post and Stirling Colgate (Livermore), J. Tuck (Los Alamos), W. H. Bostick (Stevens Institute of Technology and Livermore), E. Friedman (Princeton University), and A. C. Kolb (U.S. Naval Research Laboratory). The reason for the great interest in trying to obtain controlled thermonuclear power was outlined by Post as follows. Past history shows that our power requirements double every 10 years. If this continues, a century from now we will use energy at 1000 times the present rate. Our currently known reserves of oil would furnish this energy for only 2 months, our coal for 3 years, and our fissionable material for 25 years, but the energy available in the deuterium

in the oceans of the world would furnish this power for 1 million years. One obtained the impression from the session that controlled thermonuclear power would eventually be obtained but that a great deal of scientific investigation would be required before we learn how to heat the thermonuclear fuel to the required temperature (about 100 million degrees Kelvin) and how to hold it at that temperature long enough to get useful thermonuclear power. However, a great deal will be learned, in the process, about high-temperature physics and technology, which will be useful in many areas outside that of thermonuclear power.

Lauriston S. Taylor (National Bureau of Standards) gave a luncheon address titled "Current situation with regard to permissible radiation exposure levels." He reviewed, in considerable detail, the current problem, referring to the work of the National Committee on Radiation Protection and the International Commission on Radiation Protection. It is likely, he said, that the permissible levels of occupational radiation-exposure in industry will be reduced by a factor of 3 in the not too distant future. The chief motivating consideration is the fact that a larger fraction of the population will be exposed to radiation in their occupations; thus, a lower per capita exposure is advisable.

The chief banquet speaker was Lewis L. Strauss, chairman of the Atomic Energy Commission, who discussed a proposal, subsequently adopted by the commission, for a third round of power demonstration reactors. The program will not be limited with regard to type of reactor but lays stress on proposals to build a large, natural-uranium-fueled and heavy-water-moderated reactor and a large fluid-fuel reactor system.

The highlight of the session on experimental reactor kinetics was the four-paper presentation describing the work done by Phillips Petroleum Corporation in investigating the stability of heterogeneous reactor cores. It was reported that such a reactor usually becomes unstable when 1.5 to 2 percent excess reactivity is held in steam voids in the core—a phenomenon that is not at present understood. Motion pictures were shown of the unstable behavior of such a core.

In conjunction with the meeting, approximately 400 American Nuclear Society members took advantage of the arranged tours to visit a recently completed research reactor and other selected facilities at the U.S. Naval Research Laboratory. The meeting was very well attended, with a total of more than 1000 registrants.

C. V. STRAIN
*U.S. Naval Research Laboratory,
Washington, D.C.*

Pest-Control Chemicals in Plants

The National Academy of Sciences-National Research Council has approved the holding in October 1957 of an international conference on the fundamental processes of plant metabolism as related to the systemic action of pest-control chemicals, which include antibiotics, insecticides, fungicides, and weed-control chemicals. The conference will be patterned after the first International Conference on Use of Antibiotics in Agriculture that was held under similar auspices in October 1955. The program will include: discussion of the mode of action of antibiotics and other systemics on insects, plant diseases, and plant-growth processes; the genetic and structural aspects of plant reactions to systemic chemicals; the mechanisms of absorption and translocation as related to systemic chemical behavior; and the practical applications and limitations of systemic chemicals.

Approximately 40 American and 20 foreign scientists from the fields of plant physiology, pathology, and morphology, biochemistry, entomology, and so forth, may be invited to participate in the program. The conference will be open to all interested scientists from industry, government, and private research organizations.

If sufficient funds are assured, the conference will be held in Washington, D.C., under the auspices of the Agricultural Board-Agricultural Research Institute of the NAS-NRC Division of Biology and Agriculture and in cooperation with the U.S. Department of Agriculture. The tentative dates are 16-18 Oct. Further information may be obtained from the NAS-NRC Division of Biology and Agriculture, 2101 Constitution Ave., Washington 25, D.C.

Structure of Electrolytes

On 13-15 May the Theoretical Division of the Electrochemical Society, in conjunction with the National Science Foundation, will sponsor a symposium on the structure of electrolytic solutions at the spring meeting of the Electrochemical Society in Washington, D.C. Thirty-six papers will be presented at the 3-day symposium on all phases of fundamental studies of electrolytes. Included among the participants are 12 invited speakers from abroad.

The principal speaker at the symposium luncheon will be Peter Debye, physicist, Raytheon Manufacturing Company. General chairman for the symposium is Walter Hamer of the National Bureau of Standards. Further information may be obtained by writing to the Electrochemical Society, 216 W. 102 St., New York, N.Y.

Physics Colloquium

The 19th annual Colloquium of College Physicists will take place at the State University of Iowa, 12-15 June. The program will consist of lectures on contemporary physics by well-known physicists and round-table discussions on the teaching of physics and current problems. One evening will be devoted to an exhibit of recent publications and of original demonstration equipment and other teaching devices.

Four associated lectures will be given by R. P. Feynman of the California Institute of Technology. There will be no registration fee. For further information write to J. A. Van Allen, Department of Physics, State University of Iowa, Iowa City, Ia.

Equipment Exhibit and Symposium

The seventh annual Research Equipment Exhibit and Symposium, sponsored by research equipment manufacturers and local scientific groups, will be held 13-16 May at the National Institutes of Health, Bethesda, Md. This year's display will include the latest in electronic, optical, radiation, and surgical equipment. One hundred manufacturers will participate. An invitation to attend is extended to technical and professional people who wish an opportunity to view new research instrumentation and to exchange information with the manufacturers' technical representatives accompanying the equipment.

The symposium that is to be held concurrently with the exhibit will offer such topics as "Automation in the laboratory," "Mass spectroscopy," "Nuclear magnetic resonance and paramagnetic resonance," and "Tissue culture and its significance in bacteriology and virology." Rounding out the 4-day program will be daily motion pictures on selected scientific subjects and tours of NIH buildings and grounds. Last year's exhibit attracted approximately 5000 visitors.

Work and the Heart

The first Wisconsin Conference on Work and the Heart will be sponsored jointly by the Marquette University School of Medicine and the Wisconsin Heart Association, 15-18 May. Elston L. Belknap, director of the department of occupational and environmental medicine at Marquette is chairman of the conference, which will have the support of the American Heart Association, the National Heart Institute, and the Industrial Health Council of the American Medical Association. Publication of the proceedings is planned.

The conference will be divided into five concurrent panels on basic physiology, clinical physiology, pathology, work classification, and workmen's compensation. In each of the panels 10 to 12 participants will present a 10-minute summary of formal papers submitted by them in advance and distributed in advance among the other panelists. Following each summary will be a group discussion of the presentation. Reports from the various panels then will be presented to the full conference.

Panel moderators will be Maurice Visscher, professor of physiology at the University of Minnesota School of Medicine, basic physiology panel; Howard B. Burchell of the Mayo Clinic, Rochester, Minn., clinical physiology panel; Jesse Edwards of the Mayo Clinic pathology department, pathology panel; Leonard Goldwater, professor of occupational medicine at the Columbia University School of Public Health, work classification panel; and Rodney Beard, professor of public health and preventive medicine at the Stanford University School of Medicine, the workmen's compensation panel.

Foreign participants will include H. H. Weber of Heidelberg, Germany; Matti J. Karonen of Helsinki, Finland; A. Morgan Jones of Cheshire, England, and Gunnar Birock of Malmo, Sweden.

International Symposium on Gas Chromatography

The Analysis Instrumentation Committee of the Instrument Society of America has announced that it will hold its first 3-day International Symposium on Gas Chromatography at the Kellogg Center for Continuing Education in East Lansing, Mich., 28-30 Aug. The symposium is to be directed toward discussion of theoretical and practical advances in the field of gas chromatography as it applies to both laboratory analysis and industrial process control.

Each session will consist of a 1-hour paper on a specific phase of gas chromatography, presented by a U.S. or European authority, followed by related 10- to 15-minute contributed papers. The object of the contributed papers is to present data and theories representing the most recent developments in this important new field.

An unusual feature of the conference is the program itself, which purposely includes both active thought-stimulating sessions and relaxed recreational or leisure periods. The goal is to insure maximum interchange of information between the registrants. This is to be accomplished by conducting technical sessions from 8:30 A.M. to noon, and 7:30 to 10:30 P.M., with afternoons left open for discussion groups or recreational activity.

Full use of the Michigan State University recreational facilities, including golf course, tennis courts, and swimming pool, will be available to the registrants.

Attendance is being limited to the capacity of the Kellogg Center. The registration fee is \$20. Pre-registration is required to accommodate representatives from as many industrial and academic fields as possible. Additional information and preregistration request forms may be obtained by writing Henry J. Noebels, General Chairman, IGC Symposium, Instrument Society of America, 313 6th Ave., Pittsburgh, Pa. Contributed papers relating to specific major or minor advances in gas chromatography are now being solicited by the program chairman of the symposium, Vincent J. Coates, Perkin-Elmer Corporation, Norwalk, Conn.

Society Elections

■ National Council of Teachers of Mathematics: pres., Howard F. Fehr, Columbia University; past pres., Marie S. Wilcox; exec. sec., M. H. Ahrendt, 1201 Sixteenth St., NW, Washington 6, D.C.; rec. sec., Houston T. Karnes, Louisiana State University. The vice presidents are Francis G. Lankford, Jr., Milton W. Beckmann, Donovan A. Johnson, and Laura K. Eads.

■ American Nature Study Society: pres., Richard Weaver, University of Michigan; v. pres., H. Seymour Fowler, State Teachers College, Cedar Falls, Ia.; sec., Helen B. Ross, State Teachers College, Fitchburg, Mass.; treas., Howard Weaver, University of Illinois. Representative to the AAAS Council is E. Lawrence Palmer.

■ Society of Vertebrate Paleontology: pres., J. LeRoy Kay, Carnegie Museum; sec.-treas., Joseph T. Gregory, Peabody Museum, Yale University.

■ Western Society of Naturalists: pres., William M. Hiesey, Carnegie Institute of Washington; v. pres., Tracy I. Storer, University of California at Davis; treas., Marion Ownbey, State College of Washington; sec., John P. Harville, San Jose State College. Representatives to the AAAS Council are William M. Hiesey and Tracy I. Storer.

■ Society of Economic Paleontologists and Mineralogists: pres., Richard V. Hollingsworth, Paleontological Laboratory; past pres., Robert R. Shrock, Massachusetts Institute of Technology; v. pres., Stuart A. Levinson, Humble Oil and Refining Company; sec.-treas., Samuel P. Ellison, Jr., University of Texas. Representatives to the AAAS Council are Verner Jones and George Wilson.

Forthcoming Events

May

1-2. Image Formation and Measurement with Electronic Techniques, symp., Boston, Mass. (F. Brech, 26 Farwell St., Newtonville, Mass.)

1-3. Electronic Components Conf., Chicago, Ill. (R. M. Soria, 1830 S. 54 Ave., Chicago 50.)

1-3. Society for Experimental Stress Analysis, spring, Boston, Mass. (W. M. Murray, SESA, P.O. Box 168, Cambridge 39, Mass.)

2-3. Basic Problems of Biological Aging, internat. conf. of AIBS, Gatlinburg, Tenn. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

2-4. American Philosophical Assoc., annual, Chicago, Ill. (W. H. Hay, Bascom Hall, Univ. of Wisconsin, Madison 6.)

2-4. Animal Disease and Human Health Conf., New York, N.Y. (Mrs. E. T. Miner, New York Acad. of Sciences, 2 E. 63 St., New York 21.)

2-4. Illinois State Acad. of Science, annual, Normal. (R. A. Evers, Illinois Natural History Survey, Urbana.)

2-4. Kansas Acad. of Science, annual, Manhattan. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

2-4. Midwestern Psychological Assoc., annual, Chicago, Ill. (D. W. Fiske, Dept. of Psychol., Univ. of Chicago, Chicago.)

2-5. Society for American Archaeology, annual, Madison, Wis. (D. A. Baerreis, Dept. of Sociology and Anthropology, Univ. of Wisconsin, Madison 6.)

3. Engineers and Architects Conf., 4th annual, Columbus, Ohio. (G. B. Carson, College of Engineering, Ohio State Univ., Columbus 10.)

3-4. Minnesota Acad. of Science, Rochester. (B. O. Krogstad, Univ. of Minnesota, Duluth 5B.)

3-4. North Carolina Acad. of Science, annual, Winston-Salem. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

3-4. North Dakota Acad. of Science,

just select the type of balance you need—

All have

AINSWORTH precision and fine workmanship

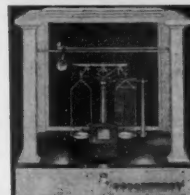
ANALYTICAL BALANCES

Trouble-free, accurate, long-lived.



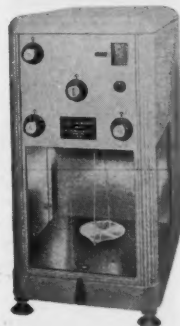
MICRO BALANCES

For high precision. Symmetrical beam, sapphire bearing.



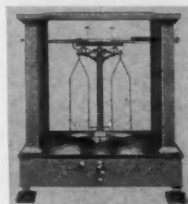
RIGHT-A-WEIGH ANALYTICAL BALANCE

Fast, direct reading, automatic.



SEMI-MICRO BALANCES

Improved faster models



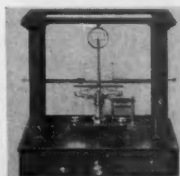
WEIGHTS

Class M, S, and S-1. (National Bureau of Standards new specifications)



ASSAY BALANCES

Used all over the world for 75 years.



For complete data see your laboratory supply dealer or write for catalog AW 13

WM. AINSWORTH & SONS, INC.
2151 LAWRENCE STREET • DENVER, COLORADO

OPTICAL BARGAINS

Fine, American-Made Instrument at
Over 50% Saving

STEREO MICROSCOPE



Up to 3" Working Distance—
Erect Image—Wide 3 Dimensional Field

Now, ready after years in development—this instrument answers the long standing need for a sturdy, efficient STEREO MICROSCOPE at low cost. Used in production—in research—in the lab, shop, factory, or at home; for inspections, examinations, counting, checking, assembling, dissecting—speeding up and improving quality control.

2 sets of objectives on no-piece give you 23 power and 40 power. Additional eyepieces available for greater or lesser magnification. A low reflection coated prism erecting system gives you an erect image—correct as to right and left—clear and sharp. Helical rack and pinion focusing. Precision, American-made 10-DAY TRIAL . . . complete satisfaction or your money back.

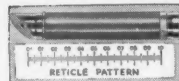
Order Stock No. 85,039-W (Shipping wt. approx. 11 lbs.)
Full price \$99.50 f.o.b. Barrington, N. J.
Send Check or M.O.

See the Stars, Moon, Planets Close Up! 3" "PALOMAR, JR." TELESCOPE 60 and 120 Power—An Unusual Buy!



Assembled—ready to use! You'll see the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Star Clusters, Moons of Jupiter in detail. Galaxies! Aluminum and overcoated 3" diameter high-speed f/10 ventilated mirror. Equatorial mount with lock on both axes. An Optical Finder Telescope, always so essential, is also included. Sturdy, hardwood, portable tripod. Order by Stock No. — Send check or M.O. — Money-back guarantee!

Stock No. 85,050-W (Shipping wt. 10 lbs.)
\$29.50 f.o.b. Barrington, N. J.



MEASURING POCKET MICROSCOPE — 50 POWER

No larger than an ordinary fountain pen, this handy pocket instrument is ideal for making direct reading measurements; for checking small parts and dimensions under powerful magnification. Speeds up quality control. Instrument contains a precision, glass etched reticle calibrated for measurements up to 1/10" by .001" divisions. Estimates to .0005" can easily be made. Chrome reflector at base of instrument reflects light on object examined or measured. Sturdy construction assures long, useful service.

Stock No. 30,225-W \$7.95 Postpaid

New! 2 in 1 Combination! 50 Power MICROSCOPE and 10 Power TELESCOPE

ONLY
\$4.50
ppd.



Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects, just plain snooping.

Send Check or M.O.
Satisfaction Guaranteed

Order Stock No. 30,059-W . . \$4.50

WRITE FOR FREE CATALOG-W

Have selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, microscopes, binoculars. Hand spectroscopes, reticles, mirrors, Ronchi rulings, dozen of other hard-to-get optical items. American's No. 1 source of supply for Photographers, Hobbyists, Telescope Makers, etc.

Order by Stock No. — Send Check or M.O.
Satisfaction Guaranteed

EDMUND SCIENTIFIC CO.
BARRINGTON, NEW JERSEY

annual, Grand Forks. (B. G. Gustafson, Chemistry Dept., Univ. of North Dakota, Grand Forks.)

3-9. Food Additives, 3rd symposium, Como, Italy. (International Bureau of Analytical Chemistry of Human and Animal Food, 18, avenue de Villars, Paris 73, France.)

4-5. American Psychosomatic Soc., 14th annual, Atlantic City, N.J. (I. A. Mirsky, APS, 551 Madison Ave., New York 22.)

4-5. Population Assoc. of America, annual, Philadelphia, Pa. (D. O. Price, Inst. for Research in Social Science, Univ. of North Carolina, Chapel Hill.)

4-7. American Assoc. for Thoracic Surgery, Chicago, Ill. (H. T. Langston, 600 S. Kingshighway, St. Louis 10, Mo.)

5-7. American Soc. for Clinical Investigation, Atlantic City, N.J. (W. H. Wheat, Jr., Steven K. Herlitz, Inc., 280 Madison Ave., New York 16.)

5-9. American Ceramic Soc., 59th annual, Dallas, Tex. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

5-10. International Cong. of Otolaryngology, 6th, Washington, D.C. (P. H. Holinger, 700 N. Michigan Ave., Chicago.)

6-8. Institute on Lake Superior Geology, 3rd annual, East Lansing, Mich. (J. Zinn, Dept. of Geology, Michigan State Univ., East Lansing.)

6-9. American Trudeau Soc., 52nd annual, Kansas City, Mo. (National Tuberculosis Assoc., 1790 Broadway, New York 19.)

6-9. American Urological Assoc., Pittsburgh, Pa. (W. P. Didusch, 1120 N. Charles St., Baltimore 1, Md.)

7. International Hydrographic Conf., 7th, Monte Carlo, Monaco. (International Hydrographic Bureau, Quai des Etats-Unis, Monte Carlo.)

7-24. World Health Assembly, 10th, Geneva, Switzerland. (World Health Organization, Palais des Nations, Geneva.)

8-9. European Federation of Chemical Engineering, 12th, Amsterdam, Netherlands. (Federation, Frankfurt/Main, 7, Germany.)

8-11. American Astronomical Soc., Cambridge, Mass. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38.)

8-11. American Helicopter Soc., 13th annual, Washington, D.C. (H. M. Lounsbury, AHS, 2 E. 64 St., New York 21.)

9. Dietary Essential Fatty Acids, Assoc. of Vitamin Chemists, Chicago, Ill. (M. Freed, Dawe's Laboratories, Inc., 4800 S. Richmond St., Chicago 32.)

9-10. Microwave Ferrites and Related Devices and Their Applications, New York, N.Y. (S. Weisbaum, Bell Telephone Laboratories, Murray Hill, N.J.)

9-10. Operations Research Soc. of America, 5th annual, Philadelphia, Pa. (M. L. Ernst, P.O. Box 2176, Potomac Sta., Alexandria, Va.)

9-11. Drugs in Psychotherapy, internatl. symp., Milan, Italy. (Secretary, Pharmacology Inst., Via Andrea del Sarto 21, Milan.)

9-11. Virginia Acad. of Science, Old Point Comfort. (F. F. Smith, Box 1420, Richmond, Va.)

9-12. American Psychoanalytic Assoc., Chicago, Ill. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

10-11. Indiana Acad. of Science, Turkey Run State Park, Ind. (H. Crull, Dept. of Mathematics, Butler Univ., Indianapolis 7.)

10-11. Vocational Training and Rehabilitation of the Mentally and Physically Handicapped, Woods Schools Conf., Chicago, Ill. (J. M. MacDonald, Woods Schools, Langhorne, Pa.)

12-13. International Soc. of Bronchopneumology, cong., Philadelphia, Pa. (C. L. Jackson, 1901 Walnut St., Philadelphia 3.)

12-16. Electrochemical Soc., Washington, D.C. (H. B. Linford, 216 W. 102 St., New York 25.)

12-16. Institute of Food Technologists, annual, Pittsburgh, Pa. (C. S. Lawrence, IFT, 176 West Adams St., Chicago 3, Ill.)

13-15. Industrial Waste Conf., 12th Lafayette, Ind. (D. E. Bloodgood, Purdue Univ., Lafayette.)

13-15. Radiation Research Soc., annual, Rochester, N.Y. (A. Adelman, Nuclear Science and Engineering Corp., P.O. Box 10901, Pittsburgh 36, Pa.)

13-15. Recent Developments in Research Methods and Instrumentation, symp., Bethesda, Md. (J. A. Shannon, National Institutes of Health, Bethesda.)

13-15. Structure of Electrolytic Solutions, NSF symp., Washington, D.C. (H. B. Linford, Electrochemical Soc., 216 W. 102 St., New York 25.)

13-16. American Orthodontic Assoc., New Orleans, La. (S. D. Goal, 1037 Maison Blanche Bldg., New Orleans.)

13-16. Semiconductor Symposium, 5th annual, Washington, D.C. (H. M. Pollack, Semiconductor Div., RCA, 415 S. 5 St., Harrison, N.J.)

13-17. American Psychiatric Assoc. annual, Chicago, Ill. (D. Blain, APA, 1785 Massachusetts Ave., NW, Washington 6.)

14-16. Industrial Nuclear Technology Conf., Chicago, Ill. (L. Reiffel, Armour Research Foundation, Illinois Inst. of Technology, 10 W. 35 St., Chicago 16.)

14-16. International Soc. of Audiology, cong., St. Louis, Mo. (S. R. Silverman, 818 S. Kingshighway, St. Louis 10.)

14-18. Biochemistry of Cancer, symp. of International Union against Cancer, London, England. (E. Boyland, Chester Beatty Research Inst., Royal Cancer Hospital, Fulham Rd., London, S.W.3.)

15-16. Space Age Symposium, Southern Research Inst., Birmingham, Ala. (R. D. Osgood, Jr., Southern Research Inst., 917 S. 20 St., Birmingham 5.)

15-18. American College of Cardiology, Washington, D.C. (S. Fiske, 150 E. 71 St., New York 21.)

15-18. Work and the Heart Medical Conf., Milwaukee, Wis. (E. L. Belknap, Dept. of Occupational and Environmental Medicine, Marquette School of Medicine, Milwaukee.)

16-17. Space Age Symp., Southern Research Inst., Birmingham, Ala. (R. D. Osgood, Jr., Southern Research Inst., 2000 Ninth Ave. South, Birmingham 5.)

16-18. Engineering Industries Exposition, New York, N.Y. (H. Becher, New York State Soc. of Professional Engineers, 1941 Grand Central Terminal Bldg., New York 17.)

(See issue of 15 March for comprehensive list)

— Latest Revised Edition of — CHART OF THE ATOMS

Revised Edition
Electronic
Planetary electrons
in the completed shells

PERIODIC CHART OF THE ATOMS

The Atoms Grouped According to the Number of Outer (Valence) Electrons

Henry D. Hubbard

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

As revised by William F. Meggers
of the U. S. Bureau of Standards

The Periodic Chart of the Atoms, published exclusively by Welch, is recognized throughout the world as a most authoritative and comprehensive presentation of the principal facts about all known atoms, including artificial transuranic elements recently manufactured.

Its information is sufficiently detailed to serve the most advanced workers in atomic physics, yet it presents basic facts clearly to students of elementary high school chemistry and physics. The characteristics most used in elementary classes, such as the Atomic Number, the Atomic Weight, and the Symbol of each element, are in large display, the rest being less prominent. Its organization is such that the student is constantly made to visualize each characteristic in its proper place with respect to the whole picture of atomic structure.

The chart is beautifully lithographed in six colors on heavy chart paper with a protective coating especially treated to prevent glare. The atomic number is red, the atomic weight, black. Other color differentiations make the symbols easily distinguished and their meaning clear.

Explanatory Key Included

A comprehensive, 48-page, key booklet is furnished with each chart. This booklet contains a brief discourse on the atom, a detailed explanation of the data given on the chart, a bibliography, and a discussion of the periodic law. Numerous tables and graphs, each containing the latest authoritative data, and a large black and white reproduction of the chart, are included. The chart is 42 x 58 inches.

The Welch Chart of the Atoms is a greatly expanded and improved presentation of Mendeleev's Periodic Table. The original edition was designed in 1924 by Henry D. Hubbard of the National Bureau of Standards. Since his death both the chart and the key have been revised through several editions by William F. Meggers, Chief of the Spectroscopy Section of the Bureau.

W. M. WELCH SCIENTIFIC COMPANY

DIVISION OF W. M. WELCH MANUFACTURING COMPANY

ESTABLISHED 1880

1515 Sedgwick Street, Dept. E, Chicago 10, Illinois, U.S.A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

4854. CHART OF THE ATOMS. Latest Edition. With formed-metal chart molding at top and bottom, with eyelets for hanging.

Each, \$7.50

4854A. CHART OF THE ATOMS. Latest Edition, on Spring Roller. Mounted on a spring roller within a metal case, suitable for permanent wall mounting, and including key booklet.

Each, \$15.00

4858. KEY, For Chart of the Atoms. Many students want their personal copy of the key booklet for further study and review. Teachers often make the study of the key a class project or the subject of special reports.

Each, \$1.00. Per Dozen, \$9.00. Lot of 100, \$65.00.



Catalog RE13 describes the COMPLETE LINE OF RECO CHROMATOGRAPHIC equipment. Send for your copy today.

RESEARCH EQUIPMENT CORPORATION

1135 Third Street, Oakland, California

The Reco Electric Desalter

Effectively removes
Inorganic salts
without equivalent
losses in organic
and amino
acids.



EQUIPMENT NEWS

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to Science, Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).

■ **MAGNETIC ALLOY**, called "Supermendur," is said to have higher permeability and lower hysteresis losses at higher flux densities than any material heretofore available. The improved properties are achieved by careful control of composition and treatment. Maximum permeability is 66,000 to 20,000 gauss; remanence, 21,500 gauss; coercive force, 0.26 oersted; and saturation, 24,000 gauss. Core losses are less than 6 watt/lb at 400 cy/sec at a flux density of 100,000 lines/in². The hysteresis loop is rectangular with a flux swing of 45,500 gauss from minus remanence to plus saturation. (Bell Telephone Laboratories, Dept. S248).

■ **VACUUM-TUBE VOLTMETER** has a frequency range of 2 cy to 200 kcy/sec. Full-scale readings range from 3 mv to 1 kv in 12 ranges with 10 db steps between ranges. The instrument is equipped with

a galvanometer attenuation switch which makes it possible to obtain fast response on all measurements above 20 cy/sec; the necessary slow response is maintained between 2 and 20 cy/sec. (Millivac Instrument Corp., Dept. S216)

■ **LABELED COMPOUNDS**, both organic and inorganic, are listed with prices in a 14-page catalog. Also included is equipment for isotope laboratories. Carbon-14, phosphorus-32, sulfur-35, deuterium, and tritium compounds are among the radiochemicals listed. (Volk Radiochemical Co., Dept. S222)

■ **MOISTURE BALANCE** automatically weighs a sample after test and records the weight on a mechanical register. Timed heating of the sample is provided by radiation from a metallic heating element. The heating rate can be adjusted from 30 to 600 w. (Scientific Products, Dept. S227)

■ **REFLECTING MICROSCOPE** manufactured by R. and J. Beck, Ltd., London, uses reflecting optics to avoid chromatic aberration. The range of wavelengths that can be employed is limited only by the reflectivity of the mirrors. With the aluminum reflecting surfaces, the range extends into both the infrared and ultraviolet regions. A range of objectives is available having nominal magnifications

from 15 to 172. A second objective is used as condenser when nonvisible illumination is used. An eyepiece of the inclined type is used to observe the specimen for focusing. A movable reflector permits removal of the eyepiece from the light path; this allows the light to pass to a camera. The camera uses 35-mm film and takes up to 40 pictures 1 in. in diameter. (Ealing Corp., Dept. S230)

■ **OSCILLOSCOPE** type 403 features a full-scale range of 1 mv to 500 v in 17 steps. The instrument will resolve a 20-μv signal. Frequency response extends from direct current to 300 kcy/sec. Linear sweeps are available in 19 calibrated settings from 0.5 sec to 0.5 μsec/cm. Both driven and recurrent sweeps are available with automatic beam-brightening during the trace interval. On driven-sweep, the beam is brightened only when the sweep is triggered, permitting the shutter of a recording camera to be left open without fogging the film. Over-all accuracy of amplitude measurement on the y-axis is within 5 percent of full scale. (Allen B. DuMont Laboratories, Inc., Dept S225)

■ **SCINTILLATION SPECTROMETER** consists of a linear amplifier, a single-channel, pulse-height analyzer, a five-range integrator with a preset timer, and a regulated high-voltage power supply. The scintillation head has a 2 by 1½ in. NaI crystal. Two collimators provide directionality. One, for use in studies of thyroid uptake, accepts radiation from a 30° arc. The other is a highly directional collimator for measuring the distribution of activity in organs. (Atomic Center, Inc., Dept. S224)

■ **BORON-10** is now available from the Atomic Energy Commission for general use. About 20 lb/wk are being produced. Boron-10, an efficient absorber of thermal neutrons is used in reactor control rods and in instruments for radiation detection. The process for separation of B¹⁰ involves formation of a complex of boron trifluoride and dimethyl ether, distillation of the complex to separate B¹⁰ from B¹¹, and electrolytic separation of boron. (Hooker Electrochemical Co., Dept. S242).

■ **NEUTRON TIME-OF-FLIGHT ANALYZER** has 1024 channels adjustable in width from a minimum value of ½ μsec to essentially any higher value. The instrument records 65,535 counts per channel with a dead time of 16 μsec/count. The instrument's memory can be divided into two parts for recording simultaneous but separate events detected by two separate 512-channel analyzers. Possible readouts include a recording potentiometer and a decimal printer. (Radiation Counter Laboratories, Inc., Dept. S243).

JOSHUA STERN

National Bureau of Standards

SCIENCE, VOL. 125

ascor® pioneers speedlight research for science, medicine and industry

CASE HISTORY 107

CASE HISTORY 108

CASE HISTORY 109

ascorlight M403 Continuous Light Adapter for Photomicrography and Macrophotography

The M403 Continuous Light Adapter permits use of the same flash tube both as a continuous, adjustable viewing light and as a high-powered instantaneous flash for the photographic exposure. The M403 also enables multiple-image work as it may be adjusted to flash repetitively from ½ to 120 flashes per second. It is also ideally suited for phase contrast and is used with standard Ascor light units and power supplies.



Write to Dept. S for technical application note . . . let us show you how the M403 Adapter can best be applied to your individual lighting requirements.

Only ascor makes a complete line of speedlights



American Speedlight Corporation

63-01 METROPOLITAN AVENUE
MIDDLE VILLAGE 79, N. Y.



STUDENT MICROSCOPES

Most reasonably priced **GUARANTEED**
Microscope on the market.

Made in West Germany

**NEW DESIGN
EXCLUSIVE
SAFETY FEATURES
HIGH QUALITY OPTICS
10X OCULAR
OBJECTIVES**

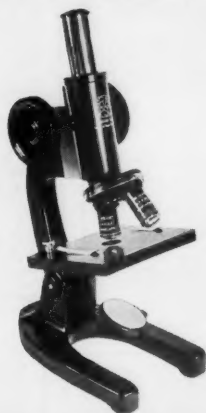
16mm (10X) N.A. 0.27
4mm (44X) N.A. 0.66

**STILL \$118.00
TEN YEAR GUARANTEE**

*Write for catalogue
listing safety features*

10% Discount on 5 or more.
Models may be assorted to ob-
tain this discount

**TRANSPORTATION
INCLUDED**



THE GRAF-APSCO CO.

5868 BROADWAY

CHICAGO 40, ILL.

AAAS SYMPOSIUM VOLUMES

6" x 9", illustrated, clothbound

Tranquilizing Drugs, 205 pp., 1957	\$5.00
Venoms, 480 pp., 1956	9.50
The Future of Arid Lands, 464 pp., 1956	6.75
Water for Industry, 140 pp., 1956	3.75
Psychopharmacology, 175 pp., 1956	3.50
The Luminescence of Biological Systems, 466 pp., 1955	7.00
Advances in Experimental Caries Research, 246 pp., 1955	6.75
Antimetabolites and Cancer, 318 pp., 1955	5.75
Monomolecular Layers, 215 pp., 1954	4.25
Fluoridation as a Public Health Measure, 240 pp., 1954	4.50
Sex in Microorganisms, 362 pp., 1954	5.75
The Present State of Physics, 271 pp., 1954	6.75
Astronomical Photoelectric Photometry, 147 pp., 1953	3.75
Soviet Science, 128 pp., 1953	1.75
Industrial Science, 160 pp., paperbound, 1952 ...	2.00

7 1/2" x 10 1/2", double column, illustrated, clothbound

Centennial, 319 pp., 1950	5.00
The Rickettsial Diseases of Man, 255 pp., 1948 ..	6.25
Approaches to Tumor Chemotherapy, 442 pp., 1947	7.75
Mammary Tumors in Mice, 231 pp., 1945	3.50

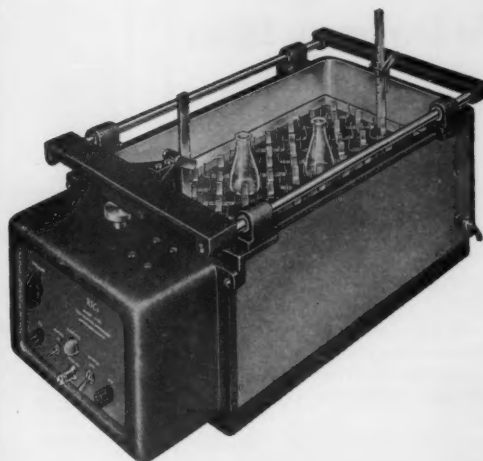
AAAS,

1515 Mass. Ave., NW, Washington 5, D.C.

TEMPERATURE CONTROLLED WATER BATH SHAKER

Model 2156

RESEARCH SPECIALTIES CO. presents its Model 2156 Water Bath Shaker, a variable speed reciprocating mechanism with a thermostatically controlled heated water bath. Engineered to provide many years of reliable, efficient, trouble-free service, the Water Bath Shaker was designed especially for use in the biological laboratory.



Standard interchangeable trays are provided in several styles to accommodate different sizes of flasks in the reciprocating rack. Racks are easily removable and are adjustable.

- **NEW DESIGN**
- **RELIABLE**
- **ADJUSTABLE**
- **EFFICIENT SERVICE**
- **LOW MAINTENANCE**
- **UNIFORM
TEMPERATURE**

WRITE FOR BULLETIN 2156

RESEARCH SPECIALTIES CO.

2005 Hopkins St.

Berkeley 7, Calif.

McGraw-Hill

Seeks

PHYSICAL SCIENTISTS

EARTH SCIENTISTS

ENGINEERS

LIFE SCIENTISTS

For Encyclopedia Editors

Is your background in physical science? earth science? engineering? or life science? Have you had editorial experience in any of these areas? Can you write well?

If so, do not overlook this opportunity to become associated with one of the most significant publishing projects ever undertaken in this country: the McGraw-Hill Encyclopedia of Science and Technology.

The McGraw-Hill Book Company has opened offices in Charlottesville, Va., to produce this multivolume encyclopedia. We are now interviewing candidates for the editorial staff. This is a once-in-a-lifetime chance for an exciting permanent job in scientific publishing, since the encyclopedia will be kept up to date by continuous revision and a yearbook will be published.

We have immediate openings for scientist-editors in these four areas: (1) physical science, (2) earth science, (3) engineering, and (4) life science.

If you are confident that you are qualified, write us about yourself. In addition to your letter, send us a complete resume of your education, experience, and vital statistics. Specify your salary requirement. Write McGraw-Hill Book Company, Box 3757, University Station, Charlottesville, Va.

PERSONNEL PLACEMENT

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

CLASSIFIED: 18¢ per word, minimum charge \$3.60. Use of Box Number counts as 10 additional words.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below — no charge for Box Number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	\$22.00 per inch
13 times in 1 year	21.00 per inch
26 times in 1 year	20.00 per inch
52 times in 1 year	19.00 per inch

For **PROOFS** on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:

Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS OPEN

Bacteriologist; 400-bed hospital, Chicago; \$5000-\$6000; M.A. desirable. Hospital experience essential. Box 85, SCIENCE. 4/5, 12

Biochemists. Assistant or associate professors (2); September 1957. To teach biochemistry in an eastern medical school; ample time and facilities for research. Ph.D. degree in biochemistry or M.D. required with several years of experience or postdoctorate work. One must be experienced in radioisotope work preferably with degree from Oak Ridge Institute of Nuclear Studies. The other should have a strong minor in physiology or pharmacology. Salary range \$6500-\$8500. Box 86, SCIENCE. 3/22, 29; 4/5

Chemical Storekeeper. Permanent full-time position involving control, issuing and inventorying chemical supplies and equipment for undergraduate and graduate level courses and research projects. B.S. degree in chemistry required. Include in reply education, experience, and desired salary. Purdue University, Chemical-Service Personnel Office, Lafayette, Indiana. X

Fishery Biologist, M.S., Ph.D., or equivalent training for full-time field research on hatchery mortality. Knowledge of bacteriology, water analysis, and parasitology necessary. Salary \$4000-\$5000, depending on qualifications. Send résumé of training to Department of Wildlife Management, Texas A. & M. College, College Station, Texas. 4/5

POSITIONS REQUIRING DEGREES IN MEDICINE OR SCIENCE: (a) Research **Bacteriologist;** supervisory position, *in vivo*, *in vitro* studies, sensitivity tests, serology, clinical bacteriology; \$5200; important eastern pharmaceutical concern. (b) Consultant **Physiologist, Ph.D.;** for developing research laboratory affiliated large general hospital; now principally cardiovascular research; to \$12,000; Mideast. (c) Assistant **Chief Biochemist;** research laboratory, large psychiatric hospital; \$5400; mid-western university city. (d) **Director of Clinical Investigation;** fairly young, experienced pharmacologist to follow up clinical trials existing drugs, initiate new trials, medical correspondence; to \$18,000; important eastern concern. Woodward Medical Personnel Bureau, 185 N. Wabash, Chicago. X

X-RAY DIFFRACTION AND FLUORESCENCE

Opening for responsible individual to take charge of new well-equipped X-ray laboratory. Experience and interest required in metallurgical, corrosion, general diffraction problems and fluorescence applications. Submit résumé and salary requirements to:

**EMPLOYMENT DEPARTMENT PP
GOODYEAR ATOMIC
CORPORATION
P.O. Box 628
PORTSMOUTH, OHIO**

POSITIONS OPEN

(a) **Internist or General Practitioner** qualified to develop as associate medical director; duties largely supervising clinical research with practicing physicians. (b) **Scientists** qualified to head groups and develop technical staffs; new research center comprised of divisions in biochemical, microbiological, organic chemistry and, also, division to handle analytical work for these divisions; large industrial company; Pacific Coast. (c) **Biochemist, Ph.D.;** teaching hospital; vicinity New York City. (d) **Director of Pharmaceutical Research and Development Program;** Ph.D.; duties include serving as consultant to top management; minimum \$12,000-\$14,000; university city, Midwest. (e) **Physiologist;** research laboratory; California. S4-1 Medical Bureau, Burnice Larson, Director, 900 N. Michigan Avenue, Chicago. X

Opening in the Department of Radiology **Isotope Laboratory** for a responsible individual; academic appointment; research opportunity; Position and salary commensurate with experience and background; minimum requirement, B.S. in physics. Submit replies to Dr. W. S. Moos, University of Illinois, 840 South Wood Street, Chicago 12, Illinois. 4/12, 19

PHYSIOLOGISTS PHARMACOLOGISTS

Ph.D.'s in physiology, pharmacology, or biochemistry with orientation in C.N.S. functions and clinical application of neuropharmacologic agents, to assist in evaluating new chemotherapeutic compounds for use in the treatment of mental illness.

ORGANIC CHEMISTS NATURAL PRODUCTS

M.S. degree or equivalent in organic chemistry with some botanical training and experience to evaluate scientific data in natural products research program.

ORGANIC CHEMISTS— GENERAL

M.S. or equivalent in organic chemistry with strong background in biological science to collaborate in analyzing and evaluating experimental data in research program.

Applicants who desire to become associated with well-established, progressive eastern pharmaceutical laboratory with liberal benefit program should submit résumé with full information to

Box 116, SCIENCE

Teaching Positions (2): Small liberal arts college, 100 miles from New York City, has openings in (a) **Biology-Zoology** and (b) **Physics**. Small classes, stimulating academic atmosphere. Emphasis on teaching, but winter field period of 8 weeks allows time and opportunity for research. Appointments to be made as assistant (\$4000-\$5000) or associate (\$5000-\$6000) professor, depending upon candidates' qualifications. Send details regarding training, experience, references and salary expected to Professor C. J. Tremblay, Chairman of Science Division, Bard College, Annandale-on-Hudson, New York. X

FELLOWSHIPS

Oceanography-Meteorology. Fellowships and research assistantships for graduates in chemistry, geology, physics, mathematics, engineering and biology; \$1800 to \$3000. Write Department of Oceanography and Meteorology, Texas A. & M. College, College Station, Texas. 4/5, 12

POSITIONS WANTED

Research Scientist, Ph.D., 30; mycology-biochemistry. Supervisory and administrative experience, capable of conducting productive, investigative programs. Industrial experience includes microbial physiology, carbohydrates, enzymes, proteins. Desires industrial research position with opportunities to serve and grow in supervisory-administrative capacity. Box 119, SCIENCE. X

PERSONNEL PLACEMENT

POSITIONS WANTED

Biochemist; Ph.D.; 12 years' experience in pharmaceutical industry—4 years, research chemist and group leader; 8 years, director of research. Medical Bureau, Burnice Larson, Director, 900 N. Michigan Avenue, Chicago. X

Pharmacologist, Ph.D. Experienced: academic research, industrial. Orientation, research, cardiovascular, radioisotopes, drug development, screening. Desires position in industry or research institution. Box 113, SCIENCE. X

POSITIONS WANTED

Botanist, woman; Ph.D. in June 1957. Desires college teaching and/or research position, preferably in the South. Major in plant physiology, minors in biochemistry and general biology. Experience in isotopic techniques; 5 years of full-time college teaching. Box 101, SCIENCE. 4/5

Virologist-Immunologist, Ph.D.; research and academic experience, publications. Will consider academic, government, or industrial position in New England. Box 118, SCIENCE. X

POSITIONS WANTED

Research Position, preferably in Canada in medical or biological field; 5 years' experience in research and instructing, B.A. Box 117, SCIENCE. X

Microbiologist-Biochemist, Ph.D.; 4 years' experience in microbial biochemistry; laboratory and plant experience in fermentation; bioassay, chromatography, manometric and tracer technique. Box 120, SCIENCE. 4/19; 5/3

SUPPLIES AND EQUIPMENT

SUPPLIES AND EQUIPMENT



The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Rates listed below — no charge for Box Number. Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	\$22.00 per inch
13 times in 1 year	21.00 per inch
26 times in 1 year	20.00 per inch
52 times in 1 year	19.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

WANTED TO PURCHASE...
SCIENTIFIC PERIODICALS AND BOOKS
Sets and runs, foreign and domestic. Entire libraries and smaller collections wanted.
WALTER J. JOHNSON, INC.
111 Fifth Avenue, New York 3, New York

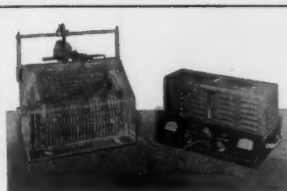
Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A35, J. S. CANNER, Inc. Boston 19, Massachusetts

PROFESSIONAL SERVICES

Project Consultation and Production Control Services in Biochemistry, Chemistry, Bacteriology, Toxicology — Insecticide Testing — Flavor Evaluation.
WRITE FOR PRICE SCHEDULE
WISCONSIN ALUMNI RESEARCH FOUNDATION
P. O. Box 2217-V • MADISON 1, WISCONSIN

FOOD RESEARCH LABORATORIES, INC.
Founded 1922
RESEARCH ANALYSES • CONSULTATION
Biological, Nutritional, Toxicological Studies
For the Food, Drug and Allied Industries
48-14 33rd STREET, LONG ISLAND CITY 1, N. Y.
Specially "What's New in Food and Drug Research" available on individual request.



KARLER-MISCO UNIT



CONTINUOUS FLOW

WRITE FOR DETAILS

MICROCHEMICAL SPECIALTIES CO.
1824 UNIVERSITY AVENUE BERKELEY 3, CALIFORNIA

albino rats *

Hypophysectomized Rats
*Descendants of the Sprague-Dawley and Wistar Strains



HENRY L. FOSTER, D.V.M.
President and Director
THE CHARLES RIVER BREEDING LABS.
Dept. B, Wilmington, Mass.



THE JUNIOR Garceau Electroencephalograph
Price \$575.00 complete.

No Batteries
Requires no Shielding
Prompt Delivery
A.C. Operated
Inkless Writing
Shipped Ready to Run

ELECTRO-MEDICAL LABORATORY, INC.
South Woodstock 2, Vermont

MICE

Swiss Webster
C3H Agouti

C-57 Black
AKR Albino

Millerton Research Farm Inc.
Millerton, N.Y. Phone 219

"OUR PREVIOUS AD

created a great deal of interest, for which we are grateful. Additional advertising in your magazine is contemplated."

Palo LABORATORY STIRRER Model #7605
\$22.55
One of complete line of laboratory-tested PALO Stirrers. Inexpensive, thoroughly reliable, suitable for most laboratory stirring operations.
Write for Bulletin X-1.
PALO LABORATORY SUPPLIES, Inc.
81 Reade St. New York 7

MICROSCOPES SCIENTIFIC INSTRUMENTS

NEW AND USED
WE BUY, SELL & TRADE

Write us what you need and what you want to dispose of.

THE TECHNICAL INSTRUMENT CO.
122 Golden Gate Ave., San Francisco 2, Calif.

POLARIMETER TUBES & ACCESSORIES

for GENERAL, SEMI-MICRO & MICRO POLARIMETRY HIGH TEMPERATURE, CONTINUOUS FLOW & INVERSION TESTS
Write for List PT-14

O. C. RUDOLPH & SONS
Manufacturers of Optical Research & Control Instruments
P.O. BOX 446 CALDWELL, N. J.

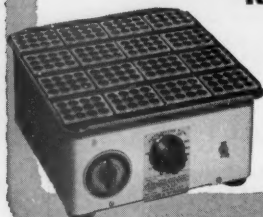
• HYPOPHYSECTOMIZED RATS

Shipped to all points via Air Express
For further information write
HORMONE ASSAY LABORATORIES, Inc.
8159 South Spaulding Ave., Chicago 29, Ill.

YANKEE® Rotators and Shakers will fulfill your requirements for maximum accuracy, uniformity and control in routine procedures...

These machines are engineered for heavy duty and will give long and dependable service.

ROTATORS



A-2270—130 RPM
11 x 11" platform, \$69
(or A-2271, 180 RPM)

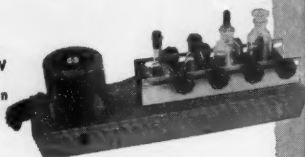
A-2273—AC Variable Speed Rotator
13 x 13" platform
60-270 RPM, \$144

A-2272—AC-DC Variable Speed Rotator
13 x 13" platform
70-210 RPM, \$97.50

SHAKERS

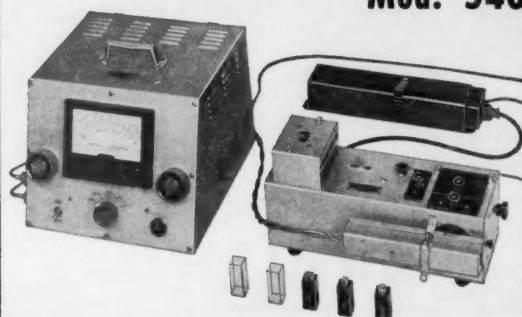
A-2305 Adams Utility Shaker—NEW
275-285 oscillations/min.
For general laboratory use and Kahn
Test Shaking, \$93

A-2300 Yankee Kahn Test Shaker
275-285 oscillations/min.
Accommodates 1 to 4 racks, for
Kahn Test, \$150



Clay-Adams Order from your dealer
NEW YORK 10

PHOTOVOLT Line-Operated Multiplier FLUORESCENCE METER Mod. 540



- High-sensitivity for measurement of low concentrations (full-scale setting for 0.001 microgram quinine sulphate)
- Micro-fluorimetry with liquid volumes as low as 1 ml
- Low blank readings, strict linearity of instrument response
- Universally applicable due to great variety of available filters, sample holders, adapters and other accessories
- Interference filters for high specificity of results and for determining spectral distribution of the fluorescent light
- High-sensitivity nephelometry for low degrees of turbidities
- Fluorescence evaluation of powders, pastes, slurries, and solids, also for spot-tests on filter paper without elution

Write for Bulletin #392 to

PHOTOVOLT CORP.

95 Madison Ave.

New York 16, N. Y.

AAAS SYMPOSIUM VOLUME

Sex in Microorganisms

Editorial Committee: D. H. WENRICH, University of Pennsylvania, *Chairman*
IVEY F. LEWIS, University of Virginia
JOHN R. RAPER, Harvard University

The genetic, physiological, and morphological evidence for "sex" in the principal groups of microorganisms—viruses, bacteria, fungi, unicellular algae, and protozoa—is presented by a group of experts in the field.

N. Visconti of the Carnegie Institution of Washington at Cold Spring Harbor, discusses recombination of "genes" in viruses. J. Lederberg of Wisconsin and E. L. Tatum of Stanford review genetic evidence for "sex" in bacteria, and W. G. Hutchinson of Pennsylvania and H. Stempen of Jefferson Medical College describe cell fusions in certain bacteria. J. R. Raper offers a comprehensive coverage of sex in fungi.

R. Patrick of the Academy of Natural Sciences, Phila-

delphia, describes syngamy in diatoms; R. A. Lewin of the Maritime Regional Laboratory, Halifax, the sexuality of other unicellular algae, especially the flagellates.

In two chapters D. H. Wenrich covers sexual phenomena in some of the protozoa and discusses the origin and evolution of sex, based primarily on the protozoa, but including material about all of the microorganisms. D. L. Nanney of Michigan summarizes mating-type phenomena in *Paramecium aurelia* and some of the recent mating-type work on Sonneborn's laboratory. C. B. Metz of Florida State compares mating-type substances in *Paramecium* and other ciliates with those found in Metazoa. Extensive chapter bibliographies are included.

6 x 9 inches; 362 pages; 59 illustrations, clothbound; 1954

Price \$5.75. Special cash price to AAAS members, \$5.00.

AAAS PUBLICATIONS

1515 Massachusetts Avenue, N.W., Washington 5, D. C.

ELASTIN

ORCEIN IMPREGNATED ELASTIN FOR
COLORIMETRIC ASSAY. SACHAR, et al.
PROC. SOC. EXP. BIOL. & MED. 90, 323 (1955)

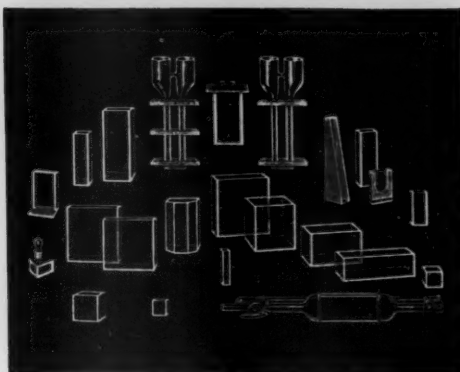
ELASTASE

CRYSTALLINE. LEWIS, et al.
J. BC. 222, 705 (1956)

Write for further information

WORTHINGTON BIOCHEMICAL CORP.
FREEHOLD, NEW JERSEY

GLASS ABSORPTION CELLS made by **KLETT**



Makers of Complete Electrophoresis Apparatus

SCIENTIFIC APPARATUS
Klett-Summerson Photoelectric Colorimeters—
Colorimeters—Nephelometers—Fluorimeters—
Bio-Colorimeters—Comparators—Glass Stand-
ards—Klett Reagents.

Klett Manufacturing Co.
179 East 87 Street, New York, New York

DE FONBRUNE MICROMANIPULATOR NEW SIMPLICITY • NEW FLEXIBILITY

FOR BIOLOGICAL AND PHYSICAL — CHEMICAL MICRO STUDIES



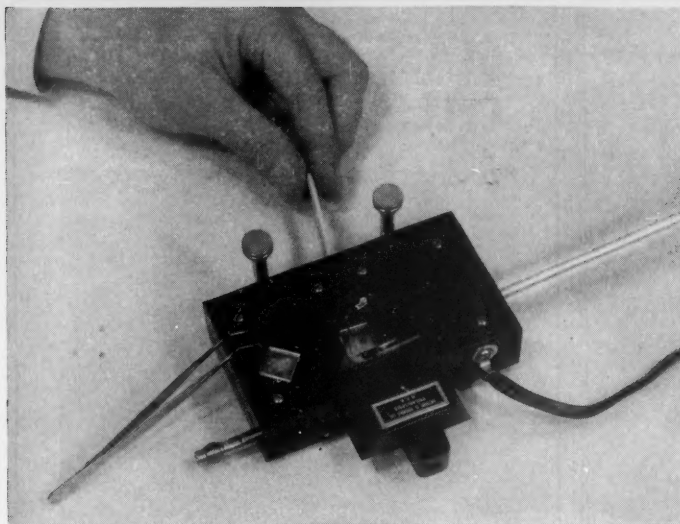
Smooth, Uniform Pneumatic Movement

A pneumatic instrument of high sensitivity and simple operation, the deFonbrune micromanipulator has proven highly satisfactory for micro studies in many fields. Pneumatic pump system provides smooth, uniform and erect movement. May be used with any type microscope... right or left hand operation. Ratio of displacement of control lever and micro tool adjustable from 1:50 to 1:2,500.

*For price and description write for
Bulletin S19-104*

aloe scientific

DIVISION OF A. S. ALOE COMPANY
5655 Kingsbury, St. Louis 12, Missouri • 14 divisions coast-to-coast



The recently published
"Fusion Methods in Chemical Microscopy",
 by Walter C. McCrone
 (Interscience Publishers, Inc., 1957),
 contains detailed techniques
 for the use of the
 McCrone Micro Cold Stage.

Thomas-McCRONE MICRO COLD STAGE

For micro fusion studies over the range -100°C to $+70^{\circ}\text{C}$

MICRO COLD STAGE (Micro Melting Point Apparatus), Thomas-McCrone Thermometer Reading Model.

With built-in heating unit to provide close temperature control within a working range of -100°C to $+70^{\circ}\text{C}$ when using dried, cooled nitrogen gas. Based on the design described by Walter C. McCrone and S. M. O'Bradovic in *Analytical Chemistry*, Vol. 28, No. 6 (June, 1956) p. 1038.

Supplements the Kofler Micro Hot Stage as a low temperature micro melting point apparatus. Also suitable for determination of characteristics of the polymorphic transformations.

Made of phenolic plastic and furnished with two nickel plated, adjustable feet for attachment to the stage of a microscope in place of stage clips. Can be used on a microscope with polarized light or phase accessories. The bevelled cut-out in the top of the stage takes a standard 10x objective. Construction has been simplified for convenient insertion of sample and to permit reproducible placement of interchangeable low temperature thermometers.

Heating is by means of a Pyrex brand E-C Radiant Glass plate. Voltage on the heating unit should not exceed 80 volts and a Variable Transformer, with mechanical stop to limit output voltage within the range 0 to 80 volts, is included with the Stage.

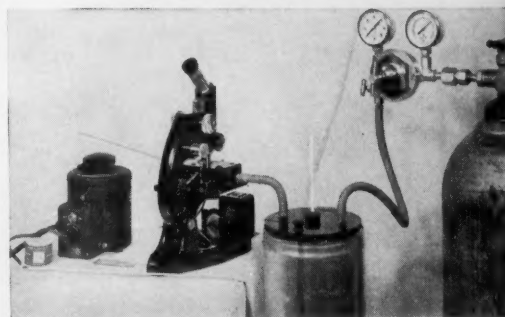
The manipulator rod for seeding, moving the glass test plate and similar operations, is inserted into the working chamber through a ball joint. Thermometers are inserted from the side and protected by means of a transparent plastic guard tube.

In use, a stream of inert gas, precooled to a temperature below the expected melting point, is passed over the sample and escapes from the stage through a small annular space around the objective. Practically all moisture is removed from the gas stream in a simple Cooling Device which is offered as an accessory. Condensation of moisture and possible icing of the objective is minimized by this positive flow of moisture free gas. The gas stream in the chamber is heated by the E-C radiant slide.

6892-G. Micro Cold Stage (Micro Melting Point Apparatus), Thomas-McCrone Thermometer Reading Model, as above described, with plastic manipulator rod with Stainless steel needle; two thermometers, range -70°C to $+70^{\circ}\text{C}$ and -100°C to $+30^{\circ}\text{C}$, respectively, in 1° divisions; transparent plastic thermometer guard; extra E-C Radiant Glass heating unit for replacement; $\frac{1}{2}$ gross glass test plates; $\frac{1}{2}$ oz. Red Label micro cover glasses, No. 1, 12 mm square; Powerstat voltage transformer; and 6-ft. cord and plug. For use on 115 volts, 60 cycles, a.c. only.179.25

6893-F. Cooling Device, for precooling the gas stream. Consisting of Dewar Flask, 4300 ml capacity, for use with dry ice and acetone, two-piece plastic cover, copper cooling coil with pressure coupling for attachment to Cold Stage, 8 inches of Silicone rubber tubing, $\frac{1}{4}$ -inch bore x $\frac{1}{8}$ -inch wall; and Thermometer, range -95°C to $+30^{\circ}$ in 1° divisions.53.75

6893-N. "Fusion Methods in Chemical Microscopy", by Walter C. McCrone, (Interscience Publishers, Inc., 1957). Contains approximately 328 pages, 158 illustrations and 23 tables, and includes techniques for both the Thomas-McCrone Cold Stage and the Kofler Hot Stage. .6.75



Complete assembly, showing Micro Cold Stage in position on microscope stage and connected with Transformer, Cooling Device for gas stream, and supply of gas



ARTHUR H. THOMAS COMPANY

More and more laboratories rely on Thomas / Laboratory Apparatus and Reagents

VINE ST. AT 3RD • PHILADELPHIA, PA.

hed
y",
rone
57),
ques
the
age.

E
°C

mas-
with
eters,
in 1°
diant
. Red
tage
ycles,
9.25

isting
tone,
pling
bing,
+30°
3.75

er C.
ately
es for
6.75



oscope
tream,

Y
ents
PA.